

INCORPORATING THE DOE-EM VISION INTO THE MIXED WASTE PROGRAM – A BALANCED PORTFOLIO

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ABSTRACT

The Department of Energy (DOE) Office of Environmental Management (EM) has established a clear vision for environmental restoration and disposition of legacy waste in the weapons complex. This vision, as described in *Accelerated Cleanup: Paths to Closure*, calls for cleanup of most of the DOE sites by 2006. The Mixed Waste Program is a key element in the DOE EM strategy.

DOE presently has about 165,000 m³ of mixed waste in inventory (mixed waste is defined as waste that is contaminated with both radioactive and hazardous components). Additionally, the various planned remedial actions throughout the DOE complex will produce significant quantities of newly generated mixed waste. Cost-effective, timely technologies must be developed, demonstrated, and **deployed** to meet the goals of the *Accelerated Cleanup: Paths to Closure* document.

Experience shows that successful deployments by EM can only be accomplished through end-user support and cohesive program elements that provide a balanced portfolio of research, development, and deployment activities. The Mixed Waste Program offers such a “balanced portfolio” through the various components that comprise the Program, including the EM Science Program (EMSP), Mixed Waste Focus Area (MWFA), Industry and University Programs, Accelerated Site Technology Deployment Program (ASTD), and various Crosscut Programs. Each of these elements has a defined role, but the boundaries between them must not be so rigid that gaps occur. Consequently, the efforts of Mixed Waste Program elements must be coordinated, such that a technology life-cycle continuum exists that provides well planned and executed development and demonstration activities, leading to actual deployment of technologies.

Over the past few years, the Mixed Waste Program has embraced this philosophy and established a technology continuum that is beginning to produce results. This paper focuses on demonstrations and deployments accomplished through the collaborative efforts of the MWFA and other supporting programs of the Mixed Waste Program. These mixed waste technology demonstrations and deployments are categorized as follows:

- Commercialization of DOE-developed technologies
- Transfer of DOE technologies to other DOE sites for demonstration and deployment
- Onsite or Complex-wide implementation of DOE-developed technologies
- DOE partnering with Industry for demonstration and deployment of technologies

The Mixed Waste Program must continue to:

- a) interface with operations end-users to understand their technology needs, and obtain validation that the technology solutions being developed meet their needs,

- b) collaboratively work with individual program elements to establish a balanced technology development, demonstration, and deployment portfolio,
- c) maintain a technology life-cycle continuum that ensures appropriate and successful technology demonstrations and deployments.

This will ensure continued and improved success in deploying technology solutions that fully resolve issues associated with final disposition of the entire DOE mixed waste inventory.

INTRODUCTION

The DOE Assistant Secretary for Environmental Management implemented policies and systems in September 1997 that were designed to establish a defensible Ten Year Plan for accomplishing cleanup of the DOE weapons complex. A guidance document (1) was issued for development of site-specific plans that describe the activities, schedule, and budget associated with cleanup of the site. Collectively, these plans constitute a document entitled *Accelerating Cleanup: Paths to Closure*. These actions were taken in direct response to the criticisms received from Congress on the Discussion Draft of DOE's first attempt at a Ten Year Plan. As discussed in the cover letter for the revised draft "Paths to Closure guidance document" from Alvin L. Alm to all DOE Operations Office Managers (October 20, 1997) (2), the House Appropriations Bill stated:

"The Committee is extremely discouraged by the Department's failure to issue a supportable Ten Year Plan for completing cleanup of the Environmental Management sites. The Committee views the repeated delays by the Department to provide a Ten Year Plan, as symptomatic of broad, cultural problems that require aggressive, institutional changes."

The Paths to Closure guidance document instituted several systems that directly affect how the DOE Office of Science and Technology (OST) identifies technology needs, establishes technology solution strategies, and appropriates funding to support these strategies. The Integrated Planning, Accountability, and Budget System (IPABS) implemented by DOE establishes the Project Baseline Summary (PBS) documents as the sole budget drivers. Any activities funded by OST must be linked to at least one PBS. This is accomplished through the Needs Management System (NMS), which is a database that is used by the sites to document the needs identified for each PBS. Focus Areas then link their work packages and associated activities with the appropriate needs. However, the PBS managers have final authority to validate that a technology development, demonstration or deployment activity does, indeed, support the PBS. The sites have evaluated their site needs and documented them, through the Site Technology Coordinating Groups (STCGs), in the DOE Needs Management System (NMS) database. The result of these changes is that the Mixed Waste Program elements, particularly the MWFA, must work harder than ever to ensure that the activities being supported by the program have "buy-in" from the operations end-users.

Over the past few years, the Mixed Waste Program has greatly improved the overall effectiveness of the program, through continuous interaction with operations end-users at the sites. Consequently, a technology continuum has been established that is beginning to produce results. Through the collaborative efforts of various Mixed Waste Program elements, several

demonstrations and deployments have been, or are in the process of being, completed. These mixed waste technology demonstrations and deployments are categorized as follows:

Commercialization involves transfer of a DOE-developed technology to the private sector for use in DOE or commercial applications. The primary purpose of this type of transfer is to allow widespread use of a needed technology, without requiring multiple system installations.

Site-to-Site Transfers involve deployment, at one DOE site, of a specific treatment system or equipment that was obtained from another DOE site. The technology involved can be either DOE-developed or commercially available. The primary purpose of this type of transfer is to provide cost savings or expedite disposition schedules.

Site-Specific Deployments involve development, demonstration, and deployment of a specific technology intended to address a specific need at a specific site or sites. Typically these are long term projects that involve only DOE scientists and resources; however, the activities are often co-funded by the Office of Science and Technology (EM-50) and operations offices such as Waste Management (EM-30) or Environmental Restoration (EM-40).

Industrial Partnerships involve either joint development of a technology between DOE and an industrial partner; or joint demonstration and deployment of a commercial technology for DOE applications.

This paper specifically focuses on demonstrations and deployments accomplished through efforts of the MWFA, in collaboration with other supporting elements of the Mixed Waste Program.

BACKGROUND

In August 1993, the DOE Assistant Secretary for Environmental Management initiated a new approach for environmental research, technology development, and deployment (3). A key feature of the new approach was to identify five major problem areas for technology development associated with the cleanup of the DOE complex. The EM OST then established five "focus areas" to identify deficiencies, develop solution strategies, and implement those strategies to address the five identified problem areas. The focus areas that OST eventually settled on included: the Mixed Waste Characterization, Treatment, and Disposal, High Level Waste Tank Remediation, Decontamination and Decommissioning, Subsurface Contamination, and Nuclear Materials focus areas.

The EM OST also established three "cross-cutting" programs including Characterization, Monitoring, and Sensor Technology (CMST); Efficient Separations and Processing Technologies (ESP); and Robotic Technology Development Program (RTDP). These programs address technical issues that are common to more than one focus area. In addition, OST implemented the Industry and University Programs. The purpose of this organization is to involve the private sector, such as colleges, universities, not-for-profit institutions, and industry, in developing and implementing improved technologies that address the needs of the focus areas, through government contracting mechanisms and competitive procurement. Another key support program is the EM Science Program. The EMSP was started in response to the Galvin Report

Alternative Futures to the Department of Energy National Laboratories (4), in which Congress requested that DOE initiate a longer-term basic science research program to seek innovative cleanup methods to replace current conventional approaches, which are often costly and ineffective.

The MWFA has the primary responsibility, with support from other programs, to identify and address the needs associated with disposition of the mixed waste inventory. Presently, thirty-six DOE sites are storing about 165,000 m³ of mixed low-level, transuranic (TRU) and mixed TRU (MTRU) waste. (For purposes of this paper, the term “mixed waste” generally refers to this entire inventory.) Over 2,300 waste streams comprise the mixed waste inventory, which is heterogeneous, both physically and chemically. About 60% of the total inventory is categorized as TRU/MTRU, as defined in DOE Order 5820.2A (5). Most of this material is destined for disposal at the Waste Isolation Pilot Plant (WIPP). Disposition strategies for most of the remaining mixed waste inventory are described in the Site Treatment Plan Consent Orders, which were established between DOE sites and host states in accordance with the Federal Facilities Compliance Act (FFCA) of 1992.

The MWFA worked closely with operations end-users at the DOE sites, using a systematic process, to develop a technical baseline. The MWFA technical baseline is simply a prioritized set of technical deficiencies that are barriers to dispositioning the mixed waste inventory. A detailed description of the MWFA technical baseline development process is available in the report titled *Mixed Waste Focus Area Technical Baseline Report, Volume I and II*, DOE/ID-10524, Rev. 1 (April 1997) (6). The MWFA then grouped these deficiencies into eight common problem areas (i.e. work packages) to better manage the associated technology development, demonstration, and deployment activities.

Waste Characterization. Various regulatory drivers and management needs, as well as stringent WIPP waste acceptance criteria, require detailed characterization of the radioactive and hazardous components in the DOE mixed waste. Destructive analytical techniques that are presently available require physically collecting samples from each waste container. These techniques increase risk to workers and the environment, are slow and expensive, and generate secondary wastes. The non-destructive examination and assay (NDE/NDA) systems that are available alleviate some of these problems, but lack sufficient reliability to meet increasingly demanding characterization requirements.

Transuranic Waste Transportation. The Transuranic Package Transporter, Model II (TRUPACT-II) is the only certified container for shipping contact-handled TRU waste to WIPP. Strict concentration limits have been imposed on certain constituents due to the potential for hydrogen gas generation during transport. As a result, 20% to 40% of the TRU waste inventory cannot be transported in its current packaging configuration. Repackaging options increase risk to workers, increase transportation risks due to increased number of shipments, and increase handling and transportation costs dramatically.

Waste Handling. Several DOE sites have identified the need for improved waste handling techniques, particularly for remote-handled (i.e. >200 mR/hr) (RH) materials. Planned treatment and disposal methods demand new or improved technologies for handling, size reducing, and packaging RH wastes. Commercially available technologies can be used in some applications,

but, for the most part, will require adaptation due to added complexities from separation and shielding requirements.

Alternatives to Incineration. A portion of the DOE mixed waste inventory contains organic contaminants that must be destroyed, in accordance with the requirements of the Resource Conservation and Recovery Act (RCRA), prior to stabilization and disposal. However, some of these waste streams are not amenable to incineration for various reasons including regulatory constraints, co-contaminants (e.g. mercury, chlorides), and radionuclides (e.g. plutonium). Alternative oxidation technologies, thermal and non-thermal, are needed to allow disposition of these waste streams.

Off-Gas Monitoring and Filtration. The three DOE incinerators, located at Idaho National Engineering and Environmental Laboratory, Savannah River Site, and Oak Ridge Reservation, have failed to meet at least one emission or monitoring requirement of the U.S. Environmental Protection Agency (EPA) proposed rule for Maximum Achievable Control Technology (MACT) for Hazardous Waste Combustors. Specific problem areas include dioxins and furans, mercury, other hazardous metals, and other substances (e.g. chlorine). According to the current EPA schedule, the facilities must be in compliance by January 1, 2002, or cease operations. This will compromise the ability of several sites to meet compliance agreement requirements.

Mercury Contamination. Mercury is present, in a range of concentrations, in multiple DOE mixed waste streams, including large volumes of soil and debris, and several process residues. The presence of mercury in waste complicates the design of off-gas systems, stabilization of treatment residuals, and monitoring of effluents because it is highly mobile and easily vaporized. Removing mercury prior to treatment would greatly simplify the processing system and reduce costs. Elemental mercury extracted must then be amalgamated, in accordance with RCRA.

Unique Wastes. Approximately 10% of the DOE mixed waste inventory cannot be dispositioned using existing capabilities. This is due to various reasons, including: the type of hazardous contaminants, concentration and types of radionuclides, regulatory restrictions, stakeholder concerns, and resource limitations. The small volumes and unique problems of these waste streams have made them a low priority for most sites. However, collectively they represent a significant portion of the DOE mixed waste inventory. Disposition of these waste streams will require highly specialized solutions that will be strategically implemented through various approaches including site-specific deployments, multiple site collaborations, and national initiatives.

Waste Stabilization. Portland cement stabilization is the baseline technology used to reduce the leachability, in accordance with RCRA, of the sludge, soil, and other finely divided solid waste streams in the DOE mixed waste inventory. However, some of the waste streams contain salts, hazardous metals, and other contaminants (e.g. fly ash, scrubber blowdown, etc.) that make them difficult to cost-effectively stabilize using the baseline technology. A common approach to resolve this problem is to decrease the waste loading in the stabilization process, but this increases waste volume, resulting in increased transportation and disposal costs. Alternative stabilization technologies are needed that can achieve higher waste loadings for these problematic waste streams.

SUCCESSFUL DEMONSTRATIONS AND DEPLOYMENTS

The MWFA has, to varying degrees, ongoing technology development, demonstration, and deployment efforts in each of the eight problem areas discussed above. Several successful technology demonstration and deployment activities have been completed, or are ongoing. The MWFA demonstration and deployment projects can be loosely grouped into the following categories: a) commercialization, b) site-to-site transfers, c) site-specific demonstrations and deployments, and d) industrial partnerships; although, these categories often overlap. The description of each category, as used in this paper, follows:

Commercialization involves transfer of a DOE-developed technology to the private sector for use in DOE or commercial applications. The primary purpose of this type of transfer is to allow widespread use of a needed technology, without requiring multiple system installations.

Site-to-Site Transfers involve demonstration and/or deployment, at one DOE site, of a specific treatment system or equipment that was obtained from another DOE site. The technology involved can be either DOE-developed or commercially available. The primary purpose of this type of transfer is to provide cost savings or expedite disposition schedules.

Site-Specific Deployments involve development, demonstration, and deployment of a specific technology intended to address a specific need at a specific site or sites. Typically these are long term projects that involve only DOE scientists and resources; however, the activities are often co-funded by the Office of Science and Technology (EM-50) and operations offices such as Waste Management (EM-30) or Environmental Restoration (EM-40).

Industrial Partnerships involve either joint development of a technology between DOE and an industrial partner; or joint demonstration and deployment of a commercial technology for DOE applications.

Examples of specific projects in each of these categories are presented below.

Commercialization

The MWFA completed successful commercialization of polymer macroencapsulation at Envirocare of Utah during fiscal year 1996 (FY1996). Polymer macroencapsulation was developed at Brookhaven National Laboratory (BNL). In this process, drums or B-12 boxes are placed in overpack molds and molten low-density polyethylene (LDPE) is poured into and around the waste container. A specially formulated multi-viscosity LDPE is used to control cracking and shrinking, while maintaining acceptable pour characteristics. The result is a monolithic waste form that meets the definition of macroencapsulation, as provided in RCRA. A cooperative agreement was established between the DOE Idaho Operations Office (DOE-ID) and Envirocare (Instrument No. DE-FC07-95ID13372) (7) that governed this technology transfer. The terms of the cooperative agreement, which provided for in-kind support from both participants, included payment of \$960,000 to Envirocare by DOE. In return, Envirocare procured and installed equipment, established operating and safety procedures, and treated and disposed of 500,000 lbs. of mixed waste lead and debris, at an estimated cost to Envirocare of

\$890,000. Participation in the cooperative agreement was offered to the entire DOE complex. Participating sites were obligated to pay all profiling, packaging, and shipping costs. Over 2,000,000 lbs. of waste was identified for inclusion in the cooperative agreement. After negotiations with the sites, allocations were finalized and 500,000 lbs. of waste from 23 sites (including seven Navy sites) were treated and disposed. In many cases, entire waste streams were eliminated from the DOE mixed waste inventory. For the Pinellas Site, the entire mixed waste inventory, as identified in their Site Treatment Plan, was eliminated. Multiple DOE sites now routinely use polymer macroencapsulation to treat and dispose mixed waste lead and debris.

Other DOE-developed technologies are currently in the process of being commercialized. These include extrusion polymer microencapsulation, and chemically bonded phosphate ceramics (CBPC). Negotiations for these technology transfer efforts were initiated in early 1998. In addition, new negotiations have recently begun for commercialization of a sulfur polymer stabilization system for application to mercury contaminated mixed waste.

The CBPC stabilization technology was developed at Argonne National Laboratory - East (ANL-E). In this process, calcined magnesium oxide is mixed with phosphoric acid to form an acid phosphate paste. This is then mixed with waste (i.e. ash, soil, blowdown salts, sludges, finely divided solids) for 20 minutes to 30 minutes and allowed to cure for approximately 2 hours in a slightly exothermic (approximately 80°C) process. CBPC is a batch process, and the primary operating equipment is a drum-scale double-planetary mixer. Extensive testing of CBPC has been completed on several different waste matrices, including ash, soils, and salts. The resulting analyses show that the CBPC process is capable of stabilizing various matrices (with waste loadings exceeding 75 wt% in some instances) to meet or exceed RCRA Land Disposal Restrictions (LDRs). The CBPC process has been patented by ANL-E. Envirocare has procured and installed the equipment for this process and is currently testing the technology on various DOE mixed waste streams.

The polymer microencapsulation process was also developed at BNL. In this process, waste materials and LDPE are continuously fed from individual loss-in-weight hoppers (AccuRate/Merrick) into a Davis-Standard 4.5 in. single-screw extruder. Due to friction and some external heating, the temperature in the extruder exceeds the melting point of the polymer (120°C), and the action of the screw thoroughly mixes the waste and polymer. Upon cooling, this results in a monolith that is capable of meeting the RCRA LDRs for hazardous metals. The polymer microencapsulation process has been demonstrated on dry ash, soils, and salts. Water-wet waste streams must be pretreated by drying to less than 2 wt% water. Waste loadings of 50 wt% are common for most waste materials tested. The polymer microencapsulation process has been patented by BNL. Envirocare is currently leasing a Davis-Standard 4.5 in. single screw extruder system from BNL, while in the process of procuring their own equipment. The unit has been installed and testing is ongoing for several DOE waste streams.

Recently, Envirocare has expressed a strong interest in commercializing the sulfur polymer stabilization system (SPSS), demonstrated at BNL, for treatment of mixed waste mercury waste streams. The U. S. Bureau of Mines originally developed sulfur polymer cement (SPC) as a low-cost, corrosion-resistant construction material. BNL adapted this technology to stabilization of mixed waste in the SPSS, and was issued a U.S. Patent in November 1997. SPSS is a two-phase

treatment process that effectively stabilizes mercury in a final waste form that meets the RCRA LDRs. In Phase I, finely ground SPC (a mixture of 95% sulfur and 5% organic modifiers) is combined with the waste material, at room temperature, in a commercial agitated mixer to form mercuric sulfide (HgS). In Phase II, the SPC/HgS mixture is heated, to approximately 130°C to a thermoplastic range, forming a molded, leach-resistant, monolithic waste form that meets RCRA LDRs for mercury. The equipment and chemicals required for this process are commercially available, and relatively inexpensive. The MWFA is working with Envirocare to ensure successful commercialization of this technology.

Direct Chemical Oxidation (DCO) is a non-thermal organic destruction process that was developed by scientists at Lawrence Livermore National Laboratory (LLNL). The DCO technology is an ambient pressure process that uses acidified ammonium peroxydisulfate solution, an aggressive oxidant, to destroy both liquid and solid organics, while maintaining an operating temperature below 100°C. Broad categories of organic mixed wastes [i.e. neat organics, solvents, polyvinyl chloride (PVC), rubber, etc.] can be converted to carbon dioxide, water, and inorganic residues derived from the wastes. The DCO process has been successfully demonstrated on several waste matrices including contaminated soils, Trimsol, amino pyridine chloride, pentachlorophenol, hard PVC, and hard rubber. Materials and Energy Corporation (M&EC) was recently awarded a significant portion of the Broad Spectrum Procurement, which provides for DOE complex-wide treatment and disposal of several mixed waste matrices. M&EC identified the DCO process as the technology chosen to process organic waste streams treated under the Broad Spectrum Procurement. In addition, LLNL deployed the DCO process for treatment of some unique organic waste streams that contain thousands of curies of tritium, and are not acceptable at existing or planned commercial treatment facilities.

Site-to-Site Transfers

DOE has amassed a significant inventory of unused equipment and technology systems due to various reasons. Facilities get closed, programs shut down, projects are completed, and system upgrades are implemented. These types of activities leave a legacy of operational equipment, pilot-scale treatment systems, partially constructed systems, and other useful materiel available for deployment at other DOE sites. The Mixed Waste Program periodically identifies opportunities to transfer unused equipment and systems from one DOE site to another.

The Oak Ridge site identified a need for the capability to treat certain mixed waste compressed gas cylinders that could not be certified for shipment under Department of Transportation (DOT) requirements. This need was communicated to the MWFA in a proposal that was received in response to the Quick Win Program call for proposals. Through site interface, the MWFA was aware that Los Alamos National Laboratory (LANL) had previously designed and partially constructed a skid mounted unit for processing compressed gas cylinders. This work was conducted under the LANL mobile treatment unit (MTU) program. A programmatic decision was made to pursue offsite treatment for all of the LANL mixed waste inventory; consequently, the Gas Recontainerization Skid was left 90% completed. The MWFA (EM-50) and Oak Ridge (EM-30) co-funded completion, transfer, and installation of the skid. Oak Ridge subsequently treated its inventory of compressed gas cylinders.

A portable water treatment unit (PWTU) from the Idaho National Engineering and Environmental Laboratory (INEEL) was transferred to the Fernald Site in FY1997 to treat process waste waters, in support of the site cleanup and closure schedule. The PWTU, which included basic ion exchange and carbon bed filtering, had been effectively used to complete the task at the INEEL for which it was constructed, and had been placed in storage. Fernald identified an unexpected need for waste water treatment capability and identified this problem to the MWFA. This issue developed because the onsite facility identified to treat the residual waste waters, which were expected to be generated from a planned mixed waste treatment process, was decontaminated and dismantled ahead of schedule. The PWTU was transferred to Fernald, with support from the MWFA, which provided a critical need while minimizing costs to DOE.

LANL also designed and began construction of a Uranium Chips Treatment Skid; however, for the same reasons discussed above, the unit was never completed. The MWFA became aware in FY1998, through support of the EM Integration program, that LLNL is planning to build a process system for oxidizing uranium chips. Uranium chips often exhibit pyrophoricity, as defined by RCRA, and must be oxidized or stabilized to mitigate this characteristic. Preliminary designs of the LLNL system are based on some form of bleaching (i.e. sodium hypochlorite, peroxide) to chemically oxidize the uranium chips, with plans for significant development and testing. The LANL skid was designed to chemically oxidize uranium chips using sodium hypochlorite, and has been successfully demonstrated. Project engineers from both sites are now in contact and negotiations are ongoing to transfer all, or portions of, the LANL Uranium Chips Skid to LLNL. This will save DOE significant expense in system design, development, and testing since these tasks have already been completed at LANL and the data will be provided to LLNL engineers.

The RMI Titanium Ashtabula site is taking this deployment concept to new heights. Ashtabula has identified a suite of five technologies that, jointly, will be able to treat the site's entire mixed waste inventory for disposal, with potential application to other DOE sites. The selected technologies include twin-screw polymer microencapsulation, single-screw polymer macroencapsulation, molten salt oxidation, compression forming stabilization, and electro-thermal plasma treatment. These five treatment systems, which are already at the Ashtabula site, were identified and procured through the DOE excess material system. Each of the technologies has previously been successfully demonstrated at other DOE facilities. The technologies are generally pilot-scale systems, but are more than adequate to address the Ashtabula treatment needs.

Site-Specific Deployments

The computed thermal/epithermal neutron (CTEN) assay system is an improved NDA technology for characterizing drums of TRU waste. This technology was developed and is currently being deployed at LANL. The CTEN method is a differential die-away technique (DDT) passive active neutron (PAN) method, but interrogates the sample with both thermal and epithermal neutrons. Because epithermal neutrons are more penetrating in fissile material than thermal neutrons, the differential response can be analyzed to detect the occurrence of self-shielding by fissile material and measure the size of the effect. The accuracy of TRU waste assay using the active DDT technique depends upon significant corrections to compensate for the effects of the matrix material in which the TRU waste is located. The CTEN has been designed

to improve on PAN capabilities to better correct for the matrix and source effects on the measurement. Experimental results have shown that for some matrices, corrections for position dependent effects within the matrix are possible.

The DCO process described above was also a site-specific deployment. The technology was developed, demonstrated, and deployed at LLNL to address and resolve a site-specific need to treat highly tritiated organic waste streams that are not acceptable to existing commercial or DOE treatment facilities.

The EXPERT data validation system was developed, demonstrated, and deployed at the INEEL in FY1998. The EXPERT system performs initial Level 1 validation of measurement data collected from TRU waste drums using a neutron interrogation system. This will have significant positive impacts on the budget and schedule projections for the INEEL project in which 3,100 m³, approximately 20,000 waste containers, must be validated for shipment to WIPP over the next five years. This project is a requirement of the Settlement Agreement between the Governor of Idaho and DOE. The EXPERT system is expected to reduce budget requirements by as much as 60%.

One unique deployment was achieved upon completion of the Non-Destructive Assay Capability Evaluation Program. In this project, two commercial NDA systems and one DOE-developed system were tested using a set of well-characterized samples in a blind test format. The systems were tested for relative accuracy and bias in accordance with criteria defined in the DOE Carlsbad Area Office Quality Assurance Program Plan for WIPP. The tests quantified performance characteristics relative to the waste matrix and characteristics. The data resulting from this activity will be useful in certifying 55-gal drums for shipment to WIPP, resulting in complex-wide cost savings.

Industrial Partnerships

The kinetic mixer polymer microencapsulation process for stabilizing mixed waste was developed and demonstrated by BNL, through a Cooperative Research and Development Agreement (CRADA) with EcoLex Inc., a commercial plastics and equipment manufacturer. In this process, waste materials and LDPE are batch fed from loss-in-weight hoppers into the fluxing chamber of a kinetic mixer, which was originally designed for processing recycled plastics. The high-speed mixing action of the equipment completely homogenizes the waste and polymer mixture in seconds, volatilizing water and other organic compounds, which are then condensed and separated for additional treatment. This process is referred to as "fluxing", because, during this short mixing cycle, the polymer becomes molten. The kinetic mixer system, as a stand-alone process, results in a monolith that meets or exceeds the RCRA LDRs for hazardous metals. The advantage of the kinetic mixer process over polymer microencapsulation using an extruder is that, generally, waste streams with water and/or organics in excess of 2 wt% cannot be treated without being dried in an evaporator or other similar process. Using the kinetic mixer, the waste is dried and stabilized in one step. Waste streams with up to 25 wt% moisture have been successfully processed. Waste loadings of 50 wt% are common for most waste materials tested. Envirocare has established licensing and royalty agreements with BNL and EcoLex, procured the equipment, and installed it for full operations. Testing of several DOE waste streams is currently being conducted. The technology has already been successfully used

to treat a commercial ash waste stream that was particularly difficult to stabilize due to high concentrations of selenium.

Scientists at LLNL, in partnership with Bioimaging Research Inc. (BIR), developed an automated gamma-ray active and passive computed tomography (A&PCT) technique for NDA of closed 55-gallon drums. The A&PCT technology uses two separate gamma-ray measurements during operation to accommodate measurement complications. The first is an active density mapping of the waste drum matrix by an external radioactive source(s) and the second is a passive measurement of the gamma-emitting radioactive source(s). The "passive" component of the A&PCT system uses a high purity germanium (HPGe) detector to quantitatively identify, with high precision, gamma-emitting nuclides in sludge, glass, combustibles and metal matrices. This technology can also be applied to other waste forms. The existing gamma-ray nondestructive assay technology (e.g., segmented gamma-ray scanner) cannot accurately measure TRU or low-level radioactive wastes that contain heterogeneous radioactive source distribution or attenuation caused by heterogeneous matrices. The matrix and radioactive material spatial information determined from the computed tomography reconstruction process is used to arrive at a gamma attenuation corrected assay. The A&PCT system can accurately and precisely characterize TRU waste drums for shipment to the WIPP in Carlsbad, New Mexico. This technology could potentially be modified, by extending its sensitivity, and used to differentiate between TRU and low-level radioactive waste categories, which would provide significant cost savings to DOE. Nevada Test Site (NTS) has deployed the A&PCT system for certification of their TRU waste drums for shipment to WIPP.

Two commercial mercury amalgamation technologies have been successfully demonstrated by the MWFA, through the Mercury Work Group. Nuclear Fuels Services Inc. (NFS) developed a proprietary mercury amalgamation process that was demonstrated on actual DOE mercury mixed waste during FY1997. The process is now permitted and DOE sites have contracted with NFS for treatment. ADA Technologies also developed a mercury amalgamation based on formation of mercuric sulfide. The process was also successfully demonstrated by the MWFA on DOE actual mercury mixed waste. ADA is now working to obtain a RCRA permit.

The Vortec Cyclone Melter System (VCMS) has been demonstrated and will be deployed at Paducah Gaseous Diffusion Plant in FY2000. This project has been funded primarily through the Federal Environmental Technology Center (FETC) and the Industry Programs. In the VCMS process, dried or slurried waste is fed into a counter-rotating vortex where it is preheated and glass-forming additives are introduced. During this step the material is heated to between 2,200°F and 2,800°F, oxidizing any organic components. These materials are then fed into the cyclone melter where they are dispersed to the chamber walls to form a molten glass product. The molten glass product and off-gas are then fed into a separation chamber where the glass product is delivered to a water quench assembly for subsequent disposal. Paducah is planning to use the VCMS to treat over 15 million pounds of mixed waste.

The MWFA has an extensive continuous emission monitor (CEM) development, test, evaluation, and deployment program. Through the efforts of this program element, several CEMs have been evaluated and deployed. The HEST multi-metal CEM has been successfully demonstrated. The Thermo Jarrel Ash Corporation, with sponsorship from the U.S. Department of Defense-Navy,

has developed an inductively coupled plasma atomic emission spectroscopy CEM for metals. The MWFA evaluated its performance in side-by-side comparisons with two other laser induced breakdown spectroscopy systems. Based on these results, the system has been commercially deployed. After successful demonstration, a Perkin-Elmer mercury CEM was installed at the Toxic Substance Control Act Incinerator at the Oak Ridge Reservation. The MWFA, in a joint effort with CMST, tested and evaluated the Jet-REMPI dioxin CEM prototype developed by DLR Stuttgart., providing useful data to help direct future test and development efforts.

FUTURE DEMONSTRATIONS AND DEPLOYMENTS

The DOE Mixed Waste Program will continue to support the technology development required to address the needs of the DOE sites. Ongoing development and test programs will result in multiple future deployments.

The MWFA is continuing to develop better methods for performing NDA/NDE of contact-handled and RH TRU waste. Specifically, characterization methods for standard waste boxes are currently being developed. In addition, better, more effective sample analysis methods are being developed. These activities are directly addressing site-identified needs.

Likewise, ongoing and planned activities addressing material handling and packaging deficiencies associated with RH materials (e.g. remote modular waste conditioning system, formerly HANDS-55 system) will result in deployment of major technology systems. In addition, several sites have identified the need for a system to size reduce and repackage oversize RH debris. The MWFA is currently evaluating this need and will initiate a development and deployment effort this year. Material handling systems for RH waste will also provide future deployment opportunities for the MWFA.

Transportation of TRU waste is another major problem area that will most likely provide significant demonstration and deployment opportunities. The ongoing studies of Gas Getters will possibly lead to deployment of technologies that greatly enhance the existing transport systems by mitigating evolution of potentially flammable hydrogen gas in the shipping containers. The Matrix Depletion Program, which is near completion, will also provide a potential complex-wide deployment

A primary source of future demonstrations and deployments may come from the small fraction of the DOE mixed inventory referred to as “unique” waste. Evaluation of the DOE mixed waste inventory, and the planned strategies to disposition the various waste matrices, indicates that multiple, near-term deployments will be required to address and resolve these “unique” problematic waste streams. This concept is not new. Several of the deployments discussed in this paper (e.g. SPC, Gas Recontainerization Skid, kinetic mixer, and DCO) were a direct result of the MWFA Quick Win Program, which was active during FY1996 and FY1997. The Quick Win Program was directed at end-users, rather than principal investigators, and specifically targeted unique, problematic waste streams that could be dispositioned with a near term deployment.

The DOE unique waste inventory, which represents approximately 10% of the total DOE mixed waste inventory, includes: a) problematic organic wastes streams, b) highly energetic waste, c)

radioactive sources, and d) other miscellaneous unique waste. Waste streams that are grouped into these classifications are considered problematic because they cannot be dispositioned using the available, or planned, DOE or commercial capabilities. The particular characteristics of waste streams that render them “unique” are as varied and diverse as the waste streams themselves. Generally, the issues are not due to technology deficiencies, but rather site-specific, logistical, and regulatory limitations. Disposition of these waste streams will require highly specialized solutions that will be strategically implemented through various approaches including site-specific deployments, multiple site collaborations, and national initiative efforts. A thorough understanding of the problematic characteristics of unique waste streams will be key to successful deployments and final disposition. In all cases, the Mixed Waste Program will work closely with the end-users to develop integrated approaches that use commercial and DOE capabilities, as necessary, to disposition the unique waste inventory.

Unique wastes have been generally grouped into the following categories, as defined in the draft FY1999 MWFA Multi-Year Program Plan (8):

Problematic Organic Waste Streams: this category includes waste streams such as tritiated polychlorinated biphenyls (PCBs), PCBs with TRU contaminants, tritiated combustible debris that exceeds incinerator waste acceptance criteria, etc.

Highly Energetic Waste Streams: this category includes waste streams such as water reactives (i.e. sodium, lithium hydride, NaK), pyrophorics (i.e. uranium chips), high explosives, and shock sensitive materials.

Radioactive Sources: this category includes radioactive sources that no longer have a useful life. For some of these items, the need no longer exists; for others, the source has decayed below a useful level. These sources may include TRU or non-TRU alpha emitters packaged in hydrochloric acid, in liquid form, or in solid form.

Miscellaneous Problematic Waste Streams: this category includes other miscellaneous problematic waste streams such as non-defense TRU waste, non-TRU alpha contaminated materials, highly tritiated materials, small quantity waste streams, batteries, gas cylinders, and activated lead.

CONCLUSIONS

The Mixed Waste Program has experienced some successes in deploying technologies that actually reduced the DOE mixed waste inventory, and others are on the horizon. However, the Mixed Waste Program would like to increase the frequency and effectiveness of deployments. This can be accomplished through better coordination of program elements, and more interactions with the sites and end-users. This will enable the Mixed Waste Program to more effectively direct technology development and demonstration activities, such that the sites needs are thoroughly understood, incorporated into the planning, and fully addressed. If this approach is followed, the end result will be effective deployments of technologies and technology systems that directly support site-specific cleanup objectives.

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