MIXED WASTE CHARACTERIZATION, TREATMENT & DISPOSAL FOCUS AREA

Technology Summary

August 1996

The information in this book represents information available and current through February 1996.

Mixed Waste Characterization, Treatment and Disposal Focus Area Technology Summary

Contents

FIGURES

INTRODUCTION

The Office of Environmental Management (EM) is responsible for cleaning up the legacy of radioactive and chemically hazardous waste at contaminated sites and facilities throughout the U.S. Department of Energy (DOE) nuclear weapons complex, preventing further environmental contamination, and instituting responsible environmental management. Initial efforts to achieve this mission resulted in the establishment of environmental restoration and waste management programs. However, as EM began to execute its responsibilities, decision makers became aware that the complexity and magnitude of this mission could not be achieved efficiently, affordably, safely, or reasonably with existing technology.

Once the need for advanced cleanup technologies became evident, EM established an aggressive, innovative program of applied research and technology development. The Office of Technology Development (OTD) was established in November 1989 to advance new and improved environmental restoration and waste management technologies that would reduce risks to workers, the public, and the environment; reduce cleanup costs; and devise methods to correct cleanup problems that currently have no solutions.

In 1996, OTD added two new responsibilities—management of a Congressionally mandated environmental science program and development of risk policy, requirements, and guidance. OTD was renamed the Office of Science and Technology (OST).

THE EM ORGANIZATION

OST is one of seven Deputy Assistant Secretarial Offices within EM. Each Deputy Assistant Secretarial Office is discussed here, with the exception of OST (EM-50), addressed in detail later in this Introduction.

Office of the Assistant Secretary for Environmental Management (EM-1)
The Office of the Assistant Secretary for Environmental Management provides centralized direction for waste management operations, environmental restoration, and related applied research and development programs and activities within DOE. The Office of the Assistant Secretary develops EM program policy and guidance for the assessment and cleanup of inactive waste sites and facilities, and waste management operations; develops and implements an applied waste research and development program to provide innovative environmental technologies to yield permanent disposal solutions at reduced costs; and oversees the transition of contaminated facilities from various departmental programs to environmental restoration. The Assistant Secretary provides guidance to all DOE Operations Offices. Organizational relationships are shown in Figure A.

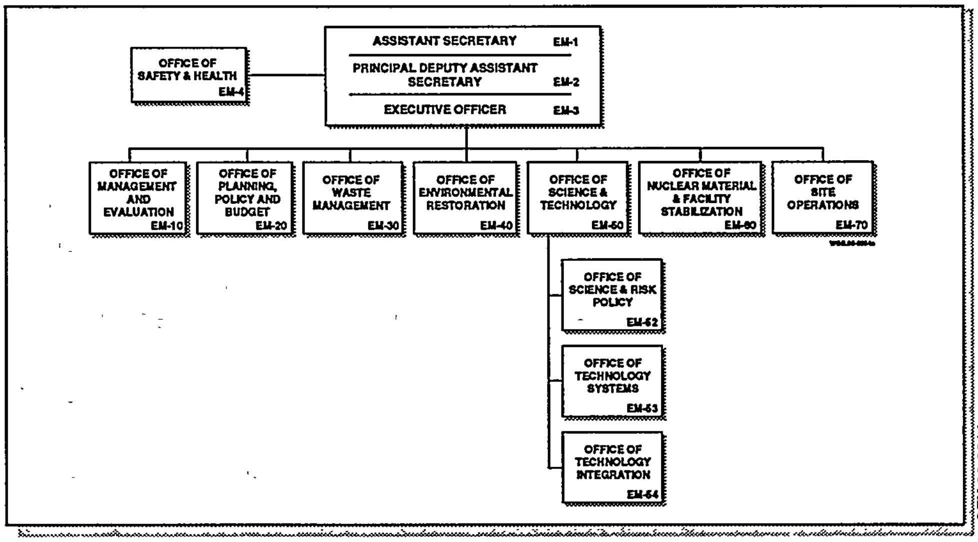

Figure A. Office of Environmental Management Organization Chart

The Office of Management and Evaluation (EM-10)

The Deputy Assistant Secretary for Management and Evaluation serves as the Assistant Secretary's principal advisor on all administrative functions and activities for EM line offices. Responsibilities include personnel administration; training and career development; total quality management; organization and manpower management; cost and performance management; space and logistics management; acquisition, procurement, and contracts management; general administrative support services; and automated data processing, automated office support systems, and information resources management.

The Office of Planning, Policy, and Budget (EM-20)

The Office of Planning, Policy, and Budget analyzes and provides support on policy and planning issues associated with environmental compliance and cleanup activities, waste management, nuclear materials and facilities stabilization, overall budget and priority setting analyses, nuclear nonproliferation policy practices, and the ultimate disposition of surplus materials and facilities. This Office is also responsible for the review, coordination, and integration of inter-site, interagency and international planning activities related to these issues. The Office coordinates policy and procedural issues associated with the external regulation of the environmental restoration, waste management, and nuclear materials and facility stabilization programs.

The Office of Waste Management (EM-30)

The Office of Waste Management provides an effective and efficient system that minimizes, treats, stores, and disposes of DOE waste as soon as possible in order to protect people and the environment from the hazards of those wastes. The Office carries out program planning and budgeting, evaluation and intervention, and representation functions associated with management of radioactive high-level, transuranic, and low-level waste; hazardous and sanitary waste; and mixed waste.

The Office of Environmental Restoration (EM-40)

The Office of Environmental Restoration remediates departmental sites and facilities to protect human health and the environment from the risks posed by inactive and surplus DOE facilities and restores contaminated areas for future beneficial use. This Office provides program direction for and management of environmental restoration activities involving inactive sites and facilities, including the decontamination of surplus facilities.

The Office of Nuclear Material and Facility Stabilization (EM-60)

The Nuclear Material and Facility Stabilization program mission is to protect people and the environment from the hazards of nuclear materials and to deactivate surplus facilities in a cost-effective manner. The Office provides program planning and budgeting, evaluation and intervention, and representation functions associated with the stabilization of nuclear materials and the deactivation of surplus facilities.

The Office of Site Operations (EM-70)

Acting to eliminate barriers and ensure that field concerns are recognized in major EM decisions, the Office of Site Operations acts as a focal point and champion for the Operations Offices and field sites, serving as facilitator, coordinator and ombudsman for crosscutting issues and topics raised by the various EM elements. The Office of Site Operations provides Headquarters policy direction for landlord planning and budgeting and sets policy and guidance to improve the effectiveness of crosscutting environment, transportation management, and waste minimization activities.

The Office of Science and Technology (EM-50)

OST manages and directs focused, solution-oriented national technology development programs to support EM by using a systems approach to reduce waste management life-cycle costs and risks to people and the environment. OST programs involve research, development, demonstration, testing, and evaluation of innovative technologies and technology systems that meet end-user needs for regulatory compliance. Activities include coordination with other stakeholders and the private sector, as well as collaboration with international organizations. In 1994, the EM program identified five major problem areas on which to focus its technology development activities (later two were combined), and implemented Focus Areas to address these problems. In addition, some needs were identified that were common to all the Focus Areas, and three Crosscutting Programs were created to address them.

OST programs establish, manage, and direct targeted, long-term research programs to bridge the gap between broad fundamental research that has wide-ranging application and needs-driven applied technology development research. OST expects to produce technologies to answer the needs of its major customers within EM for innovative science and technology through

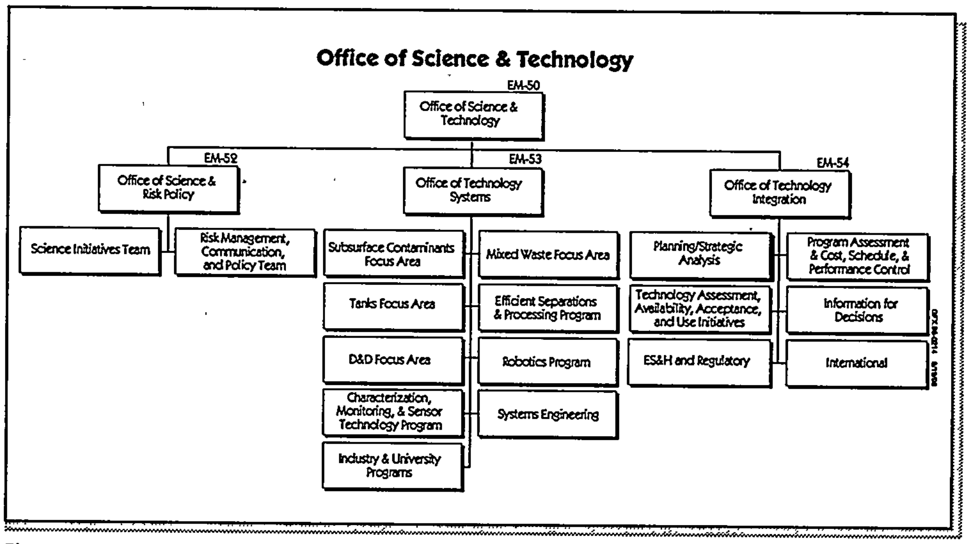

Figure B. Organization Chart of the Office of Science and Technology

integration of basic research programs, applied research programs (Focus Areas and Crosscutting Programs), industry partnerships, and technology transfer activities.

Three offices comprise OST: the Office of Science and Risk Policy, the Office of Technology Systems, and the Office of Technology Integration. The organization for OST is shown in Figure B.

Office of Science and Risk Policy (EM-52)

The Office of Science and Risk Policy manages EM's Science Program and the formulation of risk policy. The mission of this office includes the development of a targeted, long-term basic research agenda for environmental problems so that "transformational" or breakthrough approaches can lead to significant reduction in the costs and risks associated with the EM Program. This Office also bridges the gap between broad fundamental research that has wide-ranging applicability, such as that performed in DOE's Office of Energy Research, and needs-driven applied technology development that is conducted in EM's Office of Technology Systems. This Office was designed to focus the country's science infrastructure on critical national environmental management problems.

The Science Program draws on information from its DOE customers to identify necessary basic research. The Science Program concentrates its efforts on the characterization of DOE's wastes and contaminants, interactions of radioactive elements with biosystems in various natural media and waste forms, extraction and separation of radioactive and hazardous chemical contaminants, prediction and measurement of contaminant movement in DOE facilities' environments, and formulation of scientific bases for the risks associated with DOE-based contaminants.

Risk policy activities within this Office involve the development of policies, procedures, and guidance to ensure that EM activities in preventing risks to the public, workers, and the environment are within prescribed, acceptable levels. Risk evaluation methods and event and consequence analyses provide DOE with a basis for assessing both the risk and any actions being considered to reduce that risk. The Office of Science and Risk Policy ensures that advances in risk evaluation methods are integrated into coherent decision-making processes regarding risk acceptability. Decision-making processes must meet DOE missions while protecting public health, worker health and safety, ecosystem viability, and cultural and national resources.

Office of Technology Systems (EM-53)

OST programs involve research, development, demonstration, testing, and evaluation activities designed to produce innovative technologies and technology systems to meet national needs for regulatory compliance, lower life-cycle costs, and reduced risks to the environment. To optimize resources, OST has streamlined technology management activities into a single focus team for each major problem area. To ensure programs are based upon user needs, these teams include representatives from user offices within EM. There are four major problem areas upon which technology development activities are focused.

- Mixed Waste Characterization, Treatment, and Disposal
- Radioactive Tank Waste Remediation
- Subsurface Contaminants
- Decontamination and Decommissioning

Mixed Waste Characterization, Treatment, and Disposal Focus Area

DOE stores 167,000 cubic meters of mixed low-level and transuranic waste from over 1,400 mixed radioactive and hazardous waste streams at 38 sites. The Mixed Waste Characterization, Treatment, and Disposal Focus Area provides an integrated, multi-organizational, national team to develop treatment systems for the department's inventory of mixed radioactive and hazardous waste and to dispose of these low-level and transuranic waste streams in a manner that fulfills regulatory requirements.

This Focus Area plans to demonstrate three technologies to treat at least 90 percent of DOE's stored mixed waste inventory by the end of FY97. The outcome will be waste forms that are reduced in volume, as compared to the volume of stored mixed waste, and meet regulatory requirements for safe, permanent disposal. Technology development is being conducted in the areas of thermal and nonthermal treatment emissions, nonintrusive drum characterization, material handling, and final waste forms.

Radioactive Tank Waste Remediation Focus Area

The Radioactive Tank Waste Remediation Focus Area develops technologies to safely and efficiently remediate over 300 underground storage tanks that have been used to process and store more than 90 million gallons of high-level radioactive and chemical mixed waste. Technologies are needed to characterize, retrieve, and treat the waste before radioactive components are immobilized. All this must be done in a safe working environment. Emphasis is placed on in situ or remotely handled processes and waste volume minimization.

Research and development of technologies in this area is aimed at enabling tank farm closure using safe and cost-efficient solutions that are acceptable to the public and that fulfill Federal Facility Compliance Act requirements of site regulatory agreements.

Subsurface Contaminants Focus Area

The Subsurface Contaminants Focus Area is developing technologies to address environmental problems associated with hazardous and radioactive contaminants in soil and groundwater that exist throughout the DOE complex, including radionuclides, heavy metals, and dense, nonaqueous phase liquids. More than 5,700 known DOE groundwater plumes have contaminated over 600 billion gallons of water and 50 million cubic meters of soil. Migration of these plumes threatens local and regional water sources, and in some cases has already adversely impacted off-site resources. In addition, the Subsurface Contaminants Focus Area is responsible for supplying technologies for the remediation of numerous landfills at DOE facilities. These landfills are estimated to contain over 3 million cubic meters of radioactive and hazardous buried waste, some of which has migrated to the surrounding soils and groundwater. Technology developed within this specialty area will provide effective methods to contain contaminant plumes and new or alternative technologies for remediating contaminated soils and groundwater. Emphasis is placed on the development of in situ technologies to minimize waste disposal costs and potential worker exposure by treating plumes in place. While addressing contaminant plumes emanating from DOE landfills, the Subsurface Contaminants Focus Area is also working to develop new or alternative technologies for the in situ stabilization and nonintrusive characterization of these disposal sites.

Decontamination and Decommissioning Focus Area

The Decontamination and Decommissioning Focus Area is developing technologies to solve the department's challenge of deactivating 7,000 contaminated buildings and decommissioning 700 contaminated buildings. It is also responsible for decontaminating the metal and concrete within those buildings and disposing of 180,000 metric tons of scrap metal. Technology development for decontamination and decommissioning focuses on large-scale demonstrations, each of which incorporates improved technologies identified as responsive to high-priority needs. All technologies will be considered for eventual deployment, and side-by-side comparisons of improved technologies are being performed using existing commercial technologies as baselines.

Crosscutting Programs

In addition to work directed to specific Focus Areas, EM is engaged in research and development programs that cut across these problem areas. Technologies from these Crosscutting Programs may be used within two or more of the Focus Areas to help meet program goals. These programs complement and facilitate technology development in the Focus Areas as shown in Figure C. The Crosscutting Programs are:

- Characterization, Monitoring, and Sensor Technologies
- Efficient Separations and Processing
- Robotics Technology Development Program

Characterization, Monitoring, and Sensor Technologies Crosscutting Program

DOE is required to characterize more than 3,700 contaminated sites, 1.5 million barrels of stored waste, 385,000 m^3 of high-level waste in tanks, and from 1,700 to 7,000 facilities before remediation, treatment, and facility transitioning commence. Monitoring technologies are needed to ensure worker safety and effective cleanup during remediation, treatment, and site closure.

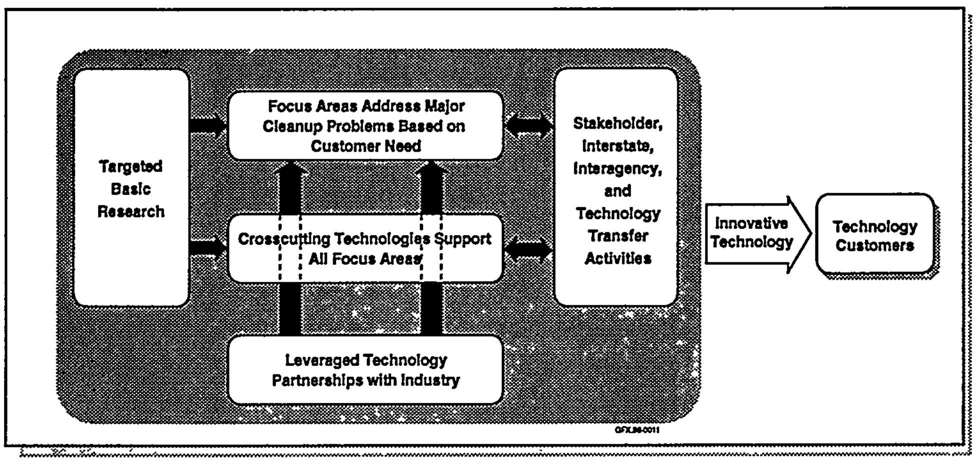

Figure C. Relationships between Focus Areas and Crosscutting Programs

Efficient Separations and Processing Crosscutting Program

Separations and selected treatment processes are needed to treat and immobilize a broad range of radioactive wastes. In some cases, treatment technologies do not exist; in others, improvements are needed to reduce costs and secondary waste volumes and to improve waste form quality. This Crosscutting Program concentrates efforts on specific high-priority needs as defined by the Focus Areas, then evaluates and adapts the technologies for other applicable Focus Areas.

This program is working to meet Federal Facilities Compliance Act milestones and other regulatory requirements, and to develop separations and treatment technologies that minimize risk, the volume of waste requiring deep, geological disposal, and secondary waste volumes.

Robotics Technology Development Crosscutting Program

Existing technologies are often inadequate to meet EM's mission needs both at a reasonable cost and under conditions that promote adequate worker safety. Robotic systems reduce worker exposure to the absolute minimum while providing proven, cost-effective, and, in some cases, the only acceptable approach to problems.

Robotics remote systems development work occurs in three areas. Remote systems for decontamination and dismantlement of facilities will reduce or eliminate extensive worker radiation protection requirements and increase productivity. Robotic systems for characterization and retrieval of stored tank waste will allow work to proceed within the radiation fields in the waste storage area. Automated chemical/radiological analysis systems are estimated to provide a cost benefit of $10.5 billion from FY96 through FY00.

INDUSTRY AND UNIVERSITY PROGRAMS

Industry and University programs provide to the Focus Areas and the Crosscutting Programs the capability to involve private industry, universities, and other interested parties in their program through direct procurement with DOE. The public-private partnerships that are established encourage the enhancement and commercialization of technologies developed by the private sector through pilot- and field-scale demonstration at DOE sites. The integration of industry, academia, and the DOE laboratories allows all aspects of the technology to be evaluated, including worker safety and health, commercial potential, and technical merit.

Industry and University activities support more than 100 agreements with the private sector. These agreements include the Small Business Innovative Research (SBIR) program, international activities, stakeholder activities, worker safety and health activities, and commercialization initiatives, as well as the direct support to the Focus Areas. For information on how to participate in these programs, see the "DOE Business Opportunities" section at the end of this book.

OFFICE OF TECHNOLOGY INTEGRATION (EM-54)

The Office of Technology Integration addresses issues that affect the involvement of critical external entities such as production/waste sites, users, the public, tribes, regulators, and commercial parties. The office is involved in the assessment, acceptability, availability, and use of improved technical solutions by providing uniform guidance, tools, and initiatives to support the Office of Technology Systems. This office also sponsors efforts to encourage and promote the involvement of affected parties' in regulatory issues.

In addition, the Office of Technology Integration sponsors domestic and international technology transfer programs within OST and coordinates planning and cost-benefit analyses with other EM organizations.

Mixed Waste Characterization, Treatment, and Disposal Focus Area Overview

The Problem

The mission of the Mixed Waste Characterization, Treatment, and Disposal Focus Area (referred to as the Mixed Waste Focus Area or MWFA) is to provide treatment systems capable of treating DOE's mixed waste in partnership with users, and with continual participation of stakeholders, tribal governments, and regulators. The MWFA deals with the problem of eliminating mixed waste from current and future storage in the DOE complex. Mixed waste is waste that contains both hazardous chemical components, subject to the requirements of the Resource Conservation and Recovery Act (RCRA), and radioactive components, subject to the requirements of the Atomic Energy Act. The radioactive components include transuranic (TRU) and low-level waste (LLW). TRU waste primarily comes from the reprocessing of spent fuel and the use of plutonium in the fabrication of nuclear weapons. LLW includes radioactive waste other than uranium mill tailings, TRU, and high-level waste, including spent fuel.

In 1992, Congress passed the Federal Facilities Compliance Act (FFCAct) mandating the treatment and permanent disposal of DOE's mixed waste inventory. As mandated by the FFCAct, DOE sites that have a mixed waste inventory have developed Site Treatment Plans (STPs) that dictate mixed waste treatment schedules. As stated in some STPs, treatment of mixed waste for a few waste streams has already begun. As estimated by the STPs, the DOE complex has approximately 167,000 m^3 of mixed waste in storage including 51,600 m^3 of mixed transuranic (MTRU) and 115,400 m^3 of mixed low-level waste (MLLW) awaiting treatment and disposal. This inventory, however, will be increased with newly generated mixed waste resulting from DOE's ongoing processes, environmental restoration, facility decontamination, and facility transition activities.

Existing treatment and disposal capacities are presently too limited to allow the treatment and disposal of DOE's inventory of mixed waste. To complicate matters, according to the STPs, there exist over 1,400 different mixed waste streams in the inventory, and these streams are located at 38 separate sites in 19 states. The mixed waste inventory has been categorized into several treatability groups. The MWFA has designed its technical program around treating these similar mixed waste streams into final waste forms which will be reduced in volume as compared to the volume of stored mixed waste, and which will meet regulatory requirements for safe, permanent disposal.

The Solution

The MWFA was formed to develop and facilitate implementation of technologies required to meet DOE's commitments for characterization, treatment, and disposal of mixed low-level and transuranic wastes. In 1995, the MWFA Lead Organization was relocated from DOE Headquarters in Germantown, Maryland, to the DOE Idaho Operations Office (DOE-ID) in Idaho Falls, Idaho. The MWFA field activities are now managed by the DOE-ID Lead Program Manager, who is responsible for planning, execution, and evaluation of project activities conducted in support of the MWFA mission. To successfully implement DOE's planned approach, the MWFA uses a systems engineering approach utilizing unique capabilities and expertise from across the DOE complex. The systems engineering approach involves continual development of a technical baseline to identify mixed waste treatment deficiencies and potential solutions to resolve these deficiencies. It also involves working closely with stakeholders, regulators, tribal governments, customers, and industrial leaders to develop solutions to treating DOE's mixed waste. An objective of this approach is to develop mixed waste treatment technologies needed by the customers, deploy the technology to private industry, and eventually have the technology manufactured by industry and bid back to the DOE Office of Environmental Management (EM) customers for their use.

To meet the objectives of the Program requires aggressive teaming with the end users within EM. The primary end users within EM include: the Office of Waste Management, EM-30; the Office of Environmental Restoration, EM-40; and the Office of Nuclear Material and Facility Stabilization, EM-60. The teaming approach is used to identify, develop, and implement needed technologies so that risk reduction and the major environmental management problems can be addressed, while cost-effectively expending funding resources. In addition, the MWFA uses the Site Technical Coordinating Groups throughout the DOE complex to obtain customer needs and to ensure customer concerns are addressed.

The MWFA Technical Baseline

To accomplish the mission of the MWFA, a technical baseline was established to form the basis for determining the specific technology development activities supported by the MWFA. The technical baseline is the prioritized list of deficiencies, as identified by customer needs and STPs, and the resulting technology development activities to resolve these deficiencies. A deficiency represents some roadblock related to a technical aspect of characterization, treatment, or handling of mixed waste. The purpose of the technical baseline is to provide strong technical justification for funding technology development, tie technology development activities to customer needs and schedules, systematically integrate technology development activities, and develop technologies only when they are not commercially available. The technical baseline is a living process that is updated periodically to contain the most complete and accurate technical basis for the MWFA.

The technical baseline development process has two phases. Phase I included the technical development and prioritization of treatment technology process flow diagrams, the identification and prioritization of the associated technology deficiencies, and the integration of these two prioritized lists to support funding calls through an aggressive procurement strategy. Phase II of the technical baseline development process will include an examination of current and proposed activities in light of the identified deficiencies. Phase II will result in the technical strategy, including the identification of specific technology development activities that will be supported by the MWFA. As such, the technical baseline will form the basis for the FY97 MWFA funding strategy. In addition to funding projects that support eliminating deficiencies, the MWFA provides an expedited mechanism to address site specific problems associated with small quantity waste streams. That mechanism augments the long term MWFA research and development projects, and is referred to as the "Quick Win Program."

PRODUCT LINE OVERVIEW

The MWFA has taken a systems approach to solving the DOE's mixed waste management problems; the MWFA has also created a product line to develop necessary ancillary subsystems that are required to complete the assembly of integrated mixed waste treatment systems. The technical product lines, or waste types, are as follows: 1) Wastewaters and Slurries, 2) Combustible Organics, 3) Sludges and Soils, 4) Solids/Debris/Soils, 5) Unique Wastes, and 6) Treatment System Technologies.

Waste Type Managers (WTMs) were selected from across the DOE complex to direct the development and demonstration of technologies that are responsive to customer needs, and to achieve compliance with regulatory requirements for treating and disposing of the mixed waste within their respective waste types. The WTM positions have been filled with individuals who are members of the MWFA's customer organizations (EM-30, EM-40, and EM-60). The WTMs are listed below.

Waste Type	**Waste Type Manager**
Wastewaters and Slurries	Cliff Brown Jr., Oak Ridge National Laboratory (ORNL)

Combustible Organics	Leon Borduin, Los Alamos National Laboratory (LANL) Dave Hutchins, DOE Oak Ridge
Sludges and Soils	Scott Anderson, Rocky Flats Environmental Technology Site (RFETS)
Solids/Debris/Soils	Mike Connolly, INEL Jim Blankenhorn, Savannah River Site (SRS)
Unique Wastes	Ron Nakaoka, LANL
Treatment System Technologies	Mary Magleby, INEL

To accomplish waste type activities, the WTM is supported by a Waste Type Team (WTT). The team provides technical support, regulatory support, and tribal and stakeholder interface to the principal investigators (PIs) from major technology development activities within the waste type. A graphical representation of how the WTT fits into the MWFA is shown in Figure D, the "MWFA Decision and Support Model." The figure depicts the flow of information from public and tribal stakeholders, regulatory agency representatives, systems analysis/engineering experts, program management/financial support, and

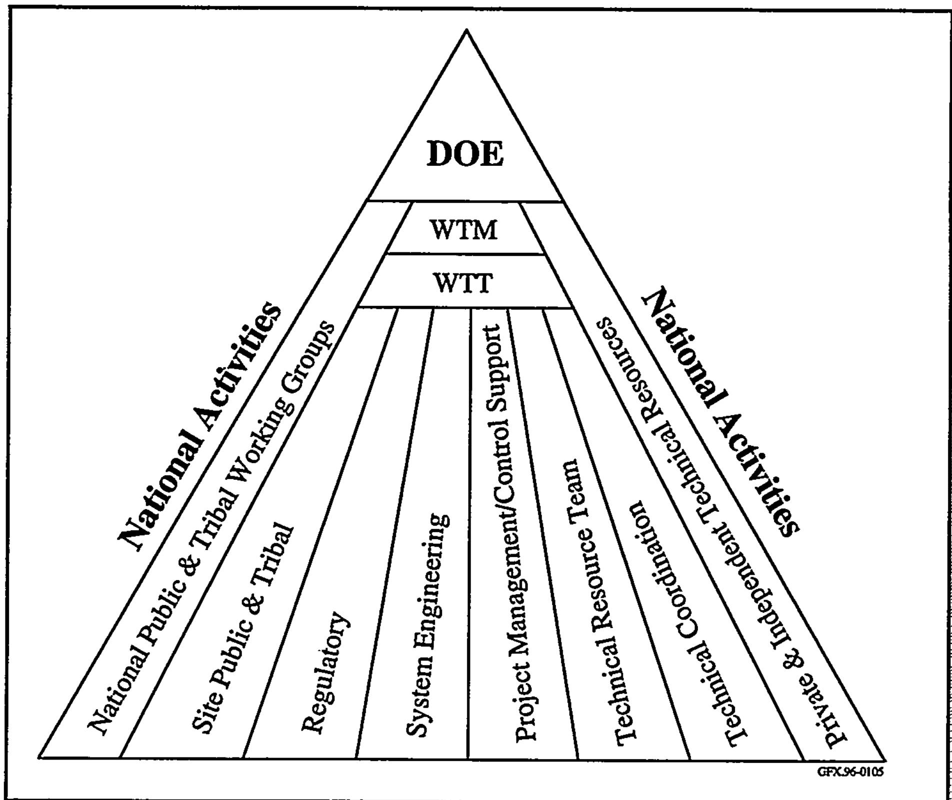

Figure D. The MWFA Decision and Support Model depicts the flow of information.

technical experts into the waste type teams and waste type managers where program technical and funding recommendations are assembled and presented to the Office of Science and Technology. Because of the national nature of the program there is also a communication/decision path from public and tribal governments, international programs, and site-related privatization activities directly to DOE-ID.

In addition to the technical product lines discussed below, the Regulatory and External Liaison Program ensures the participation of interested outside parties in the technology selection, development, evaluation, and implementation process. This program is discussed immediately following the product line discussions.

Wastewaters and Slurries

Wastewaters and Slurries are streams with less than 1 percent total organic carbon and total suspended solids of less than 30 percent. Wastewaters and Slurries represent 3.2 percent of the total mixed waste inventory. The MWFA has selected a Waste Type Manager who, in conjunction with others in the MWFA, is working towards identifying appropriate technologies for treating these waste streams, and together will select projects for funding in the near future.

Combustible Organics

Combustible Organics waste streams, which comprise approximately 1.8 percent of the total DOE complex mixed waste inventory, include liquids and slurries containing greater than 1 percent total organic carbon (TOC), and solids with a base structure that is primarily organic such that a maximum of approximately 20 percent by weight would remain as residue following incineration. Solids are defined, including sludges, as having greater than 30 percent total suspended solids (TSS).

Sludges and Soils

Sludges and Soils waste streams, which comprise approximately 46.8 percent of the total DOE complex mixed waste inventory, include waste that is at least 50 percent by volume inorganic sludges, including water. Sludges are defined as having a TSS greater than 30 percent. A sludge may be a mixture with a stabilization agent that has not properly solidified, or a mixture with absorbent materials. This category also includes inorganic particulate, paint wastes, and salt wastes.

Solids/Debris/Soils

Solids/Debris/Soils waste streams, which comprise approximately 44.5 percent of the total DOE complex mixed waste inventory, include waste that is at least 50 percent by volume materials that meet the EPA land disposal restrictions (LDR) criteria for classification as debris ("...material exceeding a 60 mm particle size that is intended for disposal..."). This category also includes waste that is estimated to be 50 percent by volume soil, including sand, silt, rock, or gravel, which does not meet the LDR criteria for debris.

Unique Wastes

Unique Wastes include lead shielding, other elemental heavy metals, batteries, fluorescent light bulbs, explosives and propellants, compressed gases, lab packs, etc., which are not included in the other waste types. Generally, acceptable treatment technologies for these mixed waste streams do not exist. Unique Wastes represent approximately 3.7 percent of the DOE mixed waste inventory.

Treatment System Technologies

Treatment System Technologies are not waste types, but rather are technologies which support the primary treatment systems under development within the Focus Area. Emphasis is placed on characterization of waste feed materials and effluents, process control, and effluent characterization using in-line, real-time continuous monitors, advanced offgas treatment techniques, and a system for offgas capture, measurement, and release.

MWFA Regulatory and External Liaison Program

The regulatory liaison organization's objective is to facilitate communication between regulatory agencies on the Federal, state, local, and tribal levels, as required, and the technical community within the MWFA. The WTTs, PIs, subcontractors, and DOE officials all must be aware of the regulatory situation within which they must operate. In addition, the MWFA is working with regulators to clearly communicate the potential advantages of the innovative technologies being developed within the MWFA as compared to accepted treatment options.

The tribal and public involvement organization of the MWFA Regulatory and External Liaison Program is responsible for facilitating meaningful tribal and public involvement within the MWFA. The goal is to enhance implementation of mixed waste treatment systems by actively involving tribal governments and stakeholders in the MWFA technology development and decision-making process.

The MWFA has involved stakeholders, tribes, and regulatory agencies through two organizations: the National Technical Workgroup (NTW) and the Interstate Technology and Regulatory Cooperation (ITRC) Work Group. The NTW was established to support the development of coordinated, consistent, and environmentally protective permit procedures for mixed waste thermal treatment. The NTW is composed of stakeholder representatives that are involved in permitting mixed waste thermal treatment technologies including DOE, EPA, the Nuclear Regulatory Commission, regulating states, and citizen groups. The objective of the ITRC is to facilitate cooperation among states in the common effort to test, demonstrate, evaluate, verify, and deploy innovative environmental technology, particularly technology related to waste management and treatment, site characterization, and site cleanup. Representatives from EPA, DOE, the Department of Defense, and regulatory agencies from 24 states comprise the ITRC.

Unlike the product lines, the MWFA Regulatory and External Liaison Program is not further discussed in other sections of this publication. Therefore, its accomplishments during the first quarter of FY96 are summarized below:

- A model was developed that identifies windows of opportunity for tribal and stakeholder involvement in the MWFA systems approach. Each "window of opportunity" is extrapolated to identify key participants, methodology, and end products.
- A white paper was issued summarizing lessons learned for obtaining a research and development permit.
- The DOE EM-50 and the International Union of Operating Engineers co-sponsored a science and technology exhibit for the U.S. Senate, October 31-November 1, 1995, in Washington, D.C. The MWFA display was featured with other EM-50 programs.
- A draft report of the MWFA Marketing and Communications Implementation Schedule was issued in November 1995. This report outlines the MWFA approach to communicate with internal and external customers, tribes, regulators, and stakeholders from a marketing perspective.
- The first working draft of the U.S. DOE MWFA Tribal and Public Involvement Plan was completed in November. This report describes how the MWFA will communicate with and involve tribal governments and stakeholders in its technology development decision-making processes and how the MWFA Tribal and Public Involvement Team will provide resources and support to the DOE Waste Type Managers and the WTT.
- A data base analysis was prepared for DOE to assist in identifying actual and potential waste streams for treatment at three DOE incinerators.

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1.0 COMBUSTIBLE ORGANICS

Combustible Organics is a waste type that includes liquids and slurries containing greater than 1 percent total organic carbon and solids which generate no more than 20 percent maximum residue as ash upon incineration. Solids are defined as materials having greater than 30 percent total suspended solids and include sludges. Combustible Organics represent approximately 1.8 percent of the mixed waste inventory and are generally amenable to incineration. There are both regulator and stakeholder concerns over incineration, however, so the Mixed Waste Focus Area (MWFA) is focusing on technologies which serve as viable alternatives to incineration. General needs for this waste type include continuous emissions monitors for organics, mercury, metals, and radionuclides; and offgas design development for a system that will capture radionuclides and metals while minimizing emission volume, secondary wastes, and potential for formation of products of incomplete combustion.

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1.1 Catalytic Chemical Oxidation (Delphi DETOX℠)

Technology Needs

The Catalytic Chemical Oxidation (CCO) system operates at temperatures much below those used in incineration and uses moderate pressures (expected operating conditions are approximately 400°F and 110 psig). Both solid and liquid wastes can be treated, and most metals are dissolved and concentrated in the reaction solution.

In a Department of Energy (DOE) project sponsored by the Morgantown Energy Technology Center (METC), the application of a CCO technology for soil remediation has been evaluated. Additional studies with other surrogates (nonradioactive) for Rocky Flats Environmental Technology Site (RFETS) wastes, including solid combustibles, are also being conducted. METC is currently sponsoring the development of a field-scale system to be tested at the Savannah River Site (SRS). This test will be shakedown testing on hazardous waste and will not be conducted on actual mixed waste.

Technical Description

CCO systems use the reaction of oxygen, or an alternate oxidizing agent, to destroy the organic constituents of a waste in an aqueous solution. In CCO, one or more chemical species are added to increase the rate at which the oxidation reactions proceed. The CCO system uses both an iron catalyst and co-catalysts to degrade the organics in a strong acid solution.

Delphi Research, Inc. has developed and patented a CCO system, called DETOX℠ (see Figure 1.1-1), which destroys hazardous organics at practical rates. This DETOX℠ technology has been demonstrated at the bench-scale, with destruction efficiencies of 99.999 percent achieved for liquid hydrocarbons (including some chlorinated organics). Due to the strongly acidic nature of the reaction mixture, engineering development focused on materials of construction, along with scale-up issues. Spent reaction solution treatment and system integration are also being addressed.

Benefits

CCO potentially offers an alternative to incineration for the treatment of combustible mixed low-level waste (MLLW). DETOX℠ can treat combustible waste at a rate comparable to incineration and reduce the bulk volume of waste without the temperatures and offgas associated with incineration. This

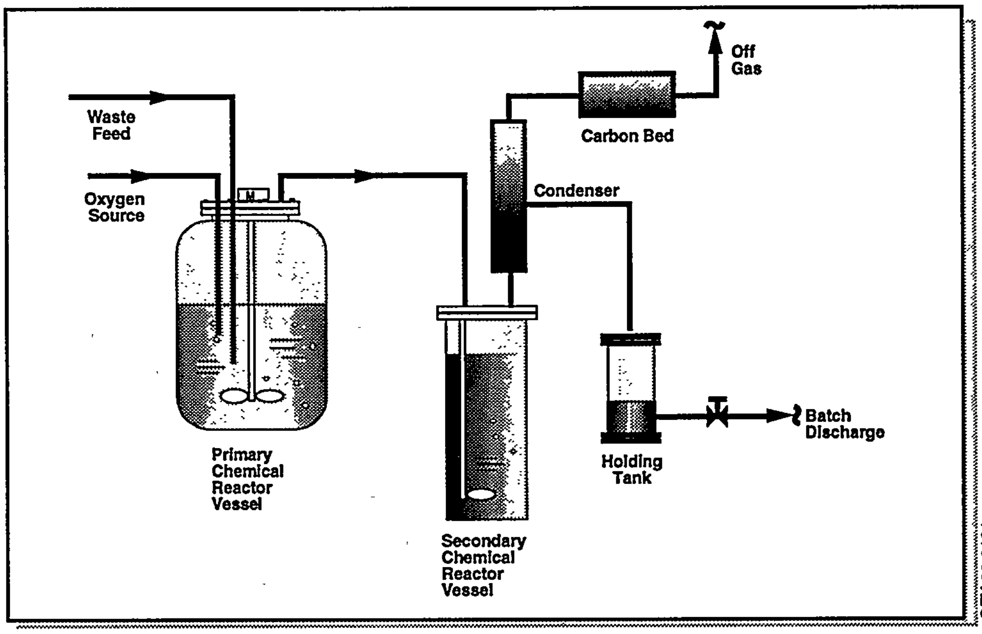

Figure 1.1-1. This simplified DETOX℠ wet chemical oxidation system destroys hazardous organics.

technology has been selected for demonstration-scale development to provide information necessary to finalize details of a production system.

COLLABORATION/TECHNOLOGY TRANSFER

SRS is supporting the initial shakedown testing of the DETOX℠ process by Delphi Research, Inc., and will provide technical support as necessary to ensure its success. Development of this technology is expected to provide opportunities for commercial application outside DOE.

ACCOMPLISHMENTS

- Completed laboratory and bench-scale tests and determined destruction efficiencies for surrogate (nonradioactive) fluidized bed incinerator oil (liquid chlorinated organics)
- Completed laboratory and bench-scale tests and determined destruction efficiencies for surrogate solid combustibles (e.g., paper, plastic)
- Completed initial materials evaluation to identify materials of construction for a demonstration system
- Completed initial solidification studies of the spent reaction solution
- Commenced fabrication of the field-scale system
- Commenced SRS activities to prepare for testing of DETOX℠ on hazardous waste

TTP Information

Catalytic Chemical Oxidation technology development activities are funded under the following technical task plans (TTPs):

TTP No. SR1-6-MW-31, "Delphi DETOX^{SM}"
TTP No. MEO-6-IP-01, "METC Industry Programs Technology Development"
TTP No. RFO-6-MW-37, "Delphi DETOX^{SM} Process Support"

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Dhooge, P.M., et al. "Advanced Development of the DETOX^{SM} Process in Application to Low-level Combustible Mixed Waste at the Rocky Flats Environmental Technology Site," Delphi Research, Inc., Albuquerque, New Mexico (September 16, 1994).

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1.2 Low Temperature Thermal Desorption

Technology Needs

Development of the low temperature thermal desorption (LTTD) system was initially funded through a Programmatic Research and Development Announcement sponsored by the DOE METC. The objective of the development is to fill a need that exists, both commercially and at DOE facilities, for a thermal desorption unit for treating small volume, solvent contaminated, waste streams. Further pilot to full-scale development and demonstration efforts are planned for FY96 and FY97 in support of the Rocky Flats Site Treatment Plan. Rocky Flats became part of this development process when RFETS conducted treatability studies on Rocky Flats Resource Conservation and Recovery Act (RCRA) waste in October 1993.

Technology Description

Thermal desorption is a cost-effective technology to treat organically contaminated soils, sludges, and other solid matrices. The objectives of the RFETS LTTD effort is to desorb and separate the hazardous contaminants, which are separated from the mixed wastes by heating the materials to temperatures from 100°C to 287°C, depending on the waste matrix. The waste can be cooled prior to shredding to control the volatilization of the organic contaminants and to more accurately determine the separation efficiency of the process. The waste material is then loaded into an indirectly heated vacuum dryer that has been equipped with agitator vanes. A heated nitrogen-carrier-gas is injected into the dryer and blankets the waste as it is agitated and brought to operating temperature. When the desired temperature is reached, the waste is subjected to a vacuum for a predetermined period of time (residence time). Organic contaminants are driven off the surface of the waste as vapors. The nitrogen-carrier-gas transfers the organic contaminated vapors to the gas treatment unit where concentrated organics and water are destroyed by flowing the gas stream through a non-thermal plasma (NTP) gas treatment system. The NTP reaction cells use electrical micro-discharges to break up organic molecules. The resultant gas then passes through high efficiency particulate air (HEPA) filters and granular activated carbon prior to venting (see Figure 1.2-1).

The LTTD technology demonstrated at Rocky Flats is the VAC*TRAX™ unit, developed by Rust Federal Services (RFS). The process was demonstrated on wastes which included surrogate low-level mixed combustibles and soils from bore hole samples. Actual Rocky Flats mixed low-level waste (MLLW) was addressed in FY96 treatability studies conducted at the Clemson Technical

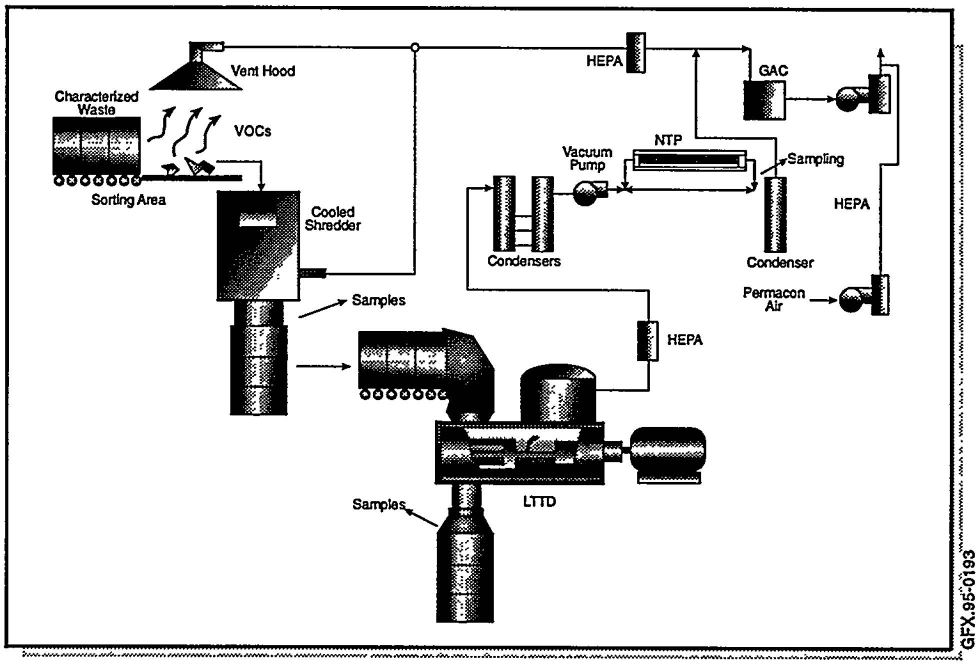

Figure 1.2-1. The LTTD system with a HEPA filter and activated carbon adsorption system treats organically contaminated soils, sludges, and other solid matrices.

Center (CTC). These studies included the testing of wet combustibles and used absorbents. The radiologic contamination levels were at approximately 10 nCi/g for the wet combustible waste and between 80 to 90 nCi/g for the used absorbents. The process demonstrated the removal the RCRA contaminants to well below land disposal restrictions and partitioning of the radiologic contaminants within the solids.

The LTTD program at RFETS is planned in three phases: 1) coordinated demonstration; 2) coordinated treatability studies; and, 3) implementation and waste treatment. The FY96 treatability studies have concluded the proof of principle phase of the program. The implementation phase, utilizing a pilot-scale unit, will begin when the conclusions drawn from the treatability studies, supported by the data, have been assessed by the regulators. An implementation demonstration of the technology, using a unit capable of processing up to 4 cubic yards of waste/batch on significant volumes of actual MLLW, is planned prior to full-scale. The unit is capable of meeting the full-scale implementation needs of RFETS and may move into full-scale operations after a proper optimization and performance testing period.

Benefits

Removal of hazardous solvents from transuranic mixed waste and MLLW streams simplifies disposal of treated waste forms, and the corresponding volume reduction achieved in separating out the hazardous compounds results in lower overall disposal costs. As a pretreatment system, LTTD renders solid waste more amenable to a final stabilization process, such as vitrification or polymer encapsulation. LTTD operates at a low temperature, typically around 100°C to 287°C. Since the nitrogen atmosphere is inert, no combustion of organic material takes place.

Collaboration/Technology Transfer

The Western Governors' Association, Develop On-Site Innovative Technology Committee, held several strategic planning meetings leading to Rocky Flats Site demonstrations in FY95 and to facilitate the resolution of interstate permitting issues. Demonstrations were held on March 8, 1995, March 23, 1995, and April 6, 1995. The demonstrations were performed on surrogates, hazardous soils, and MLLW.

Rocky Flats Technology Development, RFS, and Los Alamos National Laboratory (LANL) collaborated in the demonstration of LTTD and NTP in the treatment of MLLW at Rocky Flats. Rocky Flats has overall project management responsibilities and supplied the MLLW and the facility; Rust supplied the LTTD unit and operating engineers. LANL sought to demonstrate NTP for treating effluent gas from the LTTD and developed and built the nonthermal plasma unit.

Accomplishments

- Decontamination and return of the VAC*TRAX™ to Clemson Technical Center following the FY95 demonstration
- Shipment of actual RFETS MLLW to CTC for Treatability Studies
- Successful completion of treatability studies on low-level mixed combustible and used absorbent waste.

TTP Information

Low Temperature Thermal Desorption technology development activities are funded under the following technical task plan (TTP):

TTP No. RF1-3-MW-34, "Low Temperature Thermal Desorption"

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Palmer, C., R.L. Hemmings. "The VAC*TRAX™ Thermal Desorption Process," 1993 Incineration Conference, Knoxville, Tennessee (May 1993).

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1.3 RUSSIAN PILOT PROJECT

TECHNOLOGY NEEDS

The current focus of this project is the offgas improvement of NOx destruction technologies through the application of state-of-the-art catalysis. The offgases of particular interest are those generated in the thermal treatment of organic-based mixed wastes which are likely to contain relatively high-levels of NOx and lower but significant levels of volatile organic compounds (VOCs). Use of catalysts generally leads to improved process economics through lower processing temperatures, better selectivity, minimization (or elimination) of secondary wastes, and maximized treatment efficiency. This last item produces the desired result of achieving regulatory discharge limits for specific contaminants, or, if a specific discharge (e.g. NOx) has already been attained, increasing the offgas treatment capacity.

TECHNOLOGY DESCRIPTION

This project supports implementation of a technology evaluation and demonstration process to identify and access technology development efforts at key Former Soviet Union (FSU) institutes applicable to EM program needs. This process allows the United States to evaluate the qualifications and credentials of key FSU scientists, the potential U.S. interest, and the likelihood of success of cooperative technology development programs at relatively low risk. All technology development projects conducted in the FSU must assist in the DOE domestic cleanup mission. This TTP continues the assessment of FSU waste treatment technologies initiated in FY94, together with monitoring development of advanced/environmentally-benign catalysts for selective reduction of NOx that will meet California Land Disposal Restrictions. Catalyst development and fabrication is being performed at the Boreskov Institute of Catalysis (BIC) in Novosibirsk. The project will also assist BIC in showcasing and commercializing these catalysts in the United States.

BENEFITS

The general benefits of technology investment in FSU institutes, including the opportunity to highly leverage U.S. research and development dollars, are a better understanding of how the United States can utilize Russian technologies and scientists for the treatment of mixed waste, an improvement of offgas treatment technologies, and determination of the success ratio of cooperative technology development programs at a relatively low risk.

COLLABORATION/TECHNOLOGY TRANSFER

This project is an example of international technology transfer. The expected outcome is transfer or licensing by U.S. customers of specific Russian environmental technologies that meet DOE-EM waste management or environmental restoration needs. This project will attempt to match selected technologies with specific DOE customers and will also attempt to identify potential U.S. commercial partners willing to enter into a cooperative production and distribution agreement.

ACCOMPLISHMENTS

An annotated listing of Russian technologies recently and currently considered as candidates for demonstration in the United States has been prepared. This list was distributed to cognizant personnel in the MWFA at Idaho National Engineering Laboratory (INEL) and DOE. The Principal Investigator visited BIC in February to confirm progress on the environmentally benign NOx selective reduction catalysts. Honeycomb monoliths of three "environmentally-benign" formulations and one "baseline" formulation (IK-44/I-700) have been prepared and shipped to Lawrence Livermore National Laboratory (LLNL). Figure 1.3-1 is a picture of one of these batches.

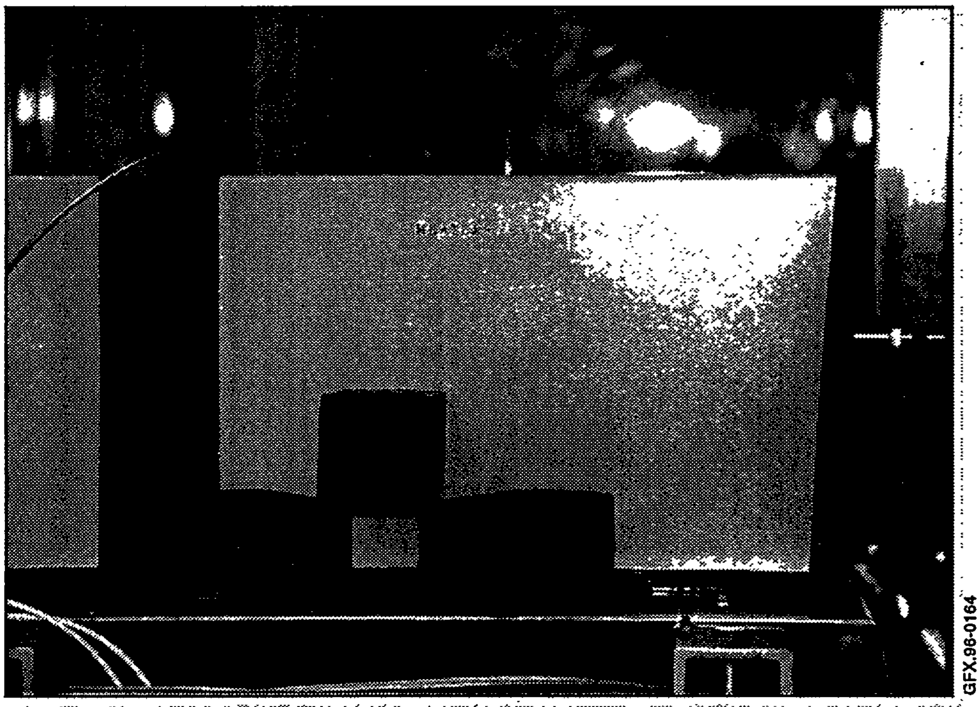

Figure 1.3-1. Environmentally-benign monolithic honeycomb catalysts (75 x 75 x 150 mm, channel - 4.2 x 4.2 mm, wall thickness - 0.8 mm) have been prepared.

TTP Information

Russian Pilot Project technology development activities are funded under the following technical task plan (TTP):

TTP No. SF2-3-MW-35a, "Russian Pilot Projects at SF"

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Bibliography of Key Publications

None available at this time.

1.4 DEMONSTRATION OF OXIDES OF NITROGEN DESTRUCTION CATALYST

TECHNOLOGY NEEDS

The current focus of this project is the improvement of offgas treatment technologies through the application of state-of-the-art catalysts. The offgases of particular interest are those generated in the thermal treatment of organic-based mixed wastes, which are likely to contain relatively high-levels of NOx. The Plasma Arc Process is one of the key technologies in DOE's plans for treating mixed low-level waste (MLLW). Due to the very high process temperature, it produces offgas with high NOx content and can greatly benefit from any improvement in catalytic NOx destruction treatment. Ammonia is important in this process because if there is insufficient ammonia, NOx is not converted to nitrogen effectively. Insufficient ammonia in the process is referred to as "ammonia slip." An improved catalyst system would potentially alleviate this issue.

TECHNOLOGY DESCRIPTION

This project supports demonstration and direct comparisons of performance between the Russian NOx removal honeycomb catalysts and Western commercially supported honeycomb catalysts. The NOx removal catalyst acquired from the BIC in Novosibirsk in 1992 consisted of an iron/chromium/zinc mixed oxide honeycomb monolith which converts excess ammonia to nitrogen. This catalyst, predominately iron oxide, has recently been modified to contain copper oxide to alleviate land disposal issues associated with chromium. This catalyst is less expensive than vanadia-titania or copper zeolite catalysts.

The original BIC NOx removal catalyst honeycombs and the advanced "environmentally benign" honeycombs are to be demonstrated in a slip stream of the DOE Western Environmental Technology Office (WETO) plasma arc offgas system at Butte, Montana. The demonstrations will allow direct comparisons of performance between the developmental BIC honeycomb catalysts and Western commercially supported honeycomb catalyst elements based on vanadia-titania.

BENEFITS

Any mixed waste treatment facility employing thermal technologies to destroy organic wastes may benefit from an effective, inexpensive, and compliant NOx removal system. The Russian catalysts appear to offer distinct advantages over Western commercial catalyst systems. The inexpensive BIC iron/chromium/zinc/copper oxides monolith honeycomb catalyst, tested previously, demonstrated high activity and the ability to alleviate the potentially costly ammonia slip issue. Since the catalyst is predominately iron oxide and since it is not a supported monolith, the material and fabrication costs should be far lower than vanadia-titania or copper zeolite catalysts. However, the high chromium and copper content still makes the use of the BIC monolith problematic due to Land Disposal Restrictions. Therefore, successful demonstration of the environmentally benign catalyst would allow this catalyst to be disposed of in an RCRA landfill.

COLLABORATION/TECHNOLOGY TRANSFER

This project is an example of international technology transfer. The expected outcome is transfer or licensing by U. S. customers of specific Russian catalyst formulations that meet DOE-EM waste management or environmental restoration NOx abatement needs. The contractor will attempt to match selected catalysts with specific DOE customers and will also attempt to identify potential U. S. commercial partners willing to enter into a cooperative production and distribution agreement.

ACCOMPLISHMENTS

As this is a new initiative, accomplishments will be discussed in future issues of this publication.

TTP INFORMATION

Demonstration of NOx Destruction Catalyst technology development activities are funded under the following technical task plan (TTP):

TTP No. SF2-3-MW-35b, "Russian Pilot Projects at SF"

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Bibliography of Key Publications

None available at this time.

1.5 Demonstration of Omnivorous Nonthermal Mixed Waste (Direct Chemical Oxidation Using Peroxydisulfate)

Technology Needs

Direct Chemical Oxidation (DCO) technology can provide oxidative destruction of organic solids or liquids by nonthermal, ambient pressure, low temperature means. These include solvents, detergents, water-insoluble oils and greases, charcoal filter media, incinerator chars and graphite, paper, plastics (with the exception of perfluorinated polymers), chlorinated and nitrated wastes, and organics immobilized in organic or inorganic matrices such as sludges. Additionally, solutions of the oxidant can be used to treat inaccessible wastes, used as a surface etching agent for contaminated metal equipment, and used in decontamination and destruction of chemical warfare agents in bulk or weaponized form.

Technology Description

The purpose of this task is to demonstrate the bench-scale use of recycled, uncatalyzed ammonium peroxydisulfate solutions to destroy surrogates for important DOE wastes and to combine these results with earlier kinetic studies to develop scale-up equations describing destruction rates as functions of system geometry, volume, and flow.

Direct chemical oxidation is proposed as a unique omnivorous technology for the destruction of organic solids and liquids in pure or undifferentiated form. The process operates within the aqueous phase at low temperature and ambient pressure. The process uses acidified ammonium peroxydisulfate solutions, and does not require any toxic, expensive, or consumable catalysts for bulk destruction. The final objective of the process is to destroy water-entrained wastes in a plug flow reactor by injecting a solution of peroxydisulfate. Broad categories of organic wastes (mixed, hazardous, or radioactively contaminated) can be converted to carbon dioxide, water, and inorganic residues derived from the wastes. Work is planned to integrate the waste oxidation process with the electrolytic recycle of the ammonium sulfate byproduct. Specific case studies will include contaminated soils, Trimsol, amino pyridine chloride, pentachlorophenol, hard PVC, and hard rubber.

Benefits

The principal benefit of this process is that it is omnivorous yet operates at ambient pressures and low temperatures. Additionally, because of the extreme oxidation potential and the formation of active sulfate free radicals, DCO can attack and destroy recalcitrant materials such as graphite, coal dust, metal carbide, charcoal and carbon residuals found in incinerator ash.

The use of peroxydisulfate does not introduce secondary wastes; the product ammonium sulfate is recycled - either concurrently in an integrated system or nonconcurrently by accumulating peroxydisulfate over time for use in infrequent campaigns. Concurrent recycle makes use of a small electrolysis cell, as peroxydisulfate is generated at very high rates relative to other electrochemical processes. At ambient temperature, ammonium peroxydisulfate solutions decompose very slowly; precipitated peroxydisulfate salts may be stored indefinitely.

Collaboration/Technology Transfer

The transfer of this technology to EM-30, EM-40, or DOD users would involve industrial participation through the supply of electrolysis equipment. Discussions with two companies that might supply equipment for a large-scale treatment facility or for a small scale transportable unit have been initiated. A Cooperative Research and Development Agreement (CRADA) and possibly a licensing agreement may be negotiated at a later date.

Accomplishments

- During the startup task (October - December 1995) a versatile bench-scale facility for testing uncatalyzed peroxydisulfate oxidation of any organic solid or liquid waste surrogate was constructed and operated. The facility consists of a plug flow reactor and several small batch or pre-reactors, operating under reflux at T=80-100°C. The facility's mass spectrometer allows continuous offgas analysis with a time resolution of approximately 1 minute, and serves to determine reaction rate (from appearance of CO_2) and to detect trace impurities.
- Shake-down tests of the plug flow reactor on model chemical ethylene glycol confirmed earlier measurements of rate.
- Pre-reactor tests on kerosene, triethylamine, cellulose rags, and tributyl phosphate showed rapid destruction. Kerosene (predominately dodecane) destruction extents were 0.99977 and 0.99991 after 70 and 140 minutes in 4 N $(NH_4)_2S_2O_8$ at 100°C. Triethylamine was oxidized to >0.9997 after 21 minutes by 3.6 N $Na_2S_2O_8$, with greater than 5 percent of the amino nitrogen converted to nitrite and nitrate, with the balance presumably to ammonium ion. Results are reported in Cooper et al., February 1996.

TTP Information

Demonstration of Omnivorous Nonthermal Mixed Waste (Direct Chemical Oxidation Using Peroxydisulfate) technology development activities are funded under the following technical task plan (TTP):

TTP No. SF2-3-MW-35c, "Russian Pilot Projects at SF"

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1.6 CLEANABLE STEEL HIGH EFFICIENCY PARTICULATE AIR FILTER

TECHNOLOGY NEEDS

Cleanable High Efficiency Particulate Air (HEPA) filters have been identified by DOE as an important need in DOE's strategy for treating mixed waste. The extensive amount of handling required for the current glass paper HEPA filters exposes workers to radioactivity. Also, the current HEPA filters are fragile and can be destroyed or their performance degraded when they become wet, hot, or overpressured. Filter failure can lead to significant environmental contamination and high cleanup costs. The glass filters cannot be cleaned and are disposed of after use, contributing to high disposal costs and more radioactive waste volume in the environment.

The use of current glass HEPA filters also increases the difficulty in having the new waste treatment processes currently under development licensed by various regulatory agencies. In the review of mixed waste incinerators, the Environmental Protection Agency (EPA) has cited HEPA filter failures due to high temperature, moisture, and overpressure conditions in potential accident scenarios. DOE is concerned that many of the problems that EPA identified with the incinerators may transfer to the new technologies being developed for treating mixed waste.

Steel filters can result in significant cost savings and increased reliability in most of the existing thermal and proposed treatment systems but will have to meet existing HEPA requirements and will therefore require additional development. The proposed new waste calciners at Hanford can use commercially available steel filters that do not meet HEPA requirements, but would benefit from further development of the filters to reduce cost. Some offgas systems contain significant halides that can corrode the stainless steel filters. In these systems, other metal compositions can be used to resist the corrosion.

TECHNOLOGY DESCRIPTION

The cleanable steel HEPA filter represents a near-term solution to the identified problems related to filter failure and waste disposal experienced with the present glass HEPA filters. It can withstand all of the high temperature, pressure, and moisture conditions that would cause structural damage to the glass HEPA filter. The high strength of the filter also allows the filter to be cleaned by rigorous methods such as reverse air pulses and acid and water washings. In contrast, the glass HEPA would be destroyed under these conditions and therefore cannot be cleaned. The high reliability and cleanability

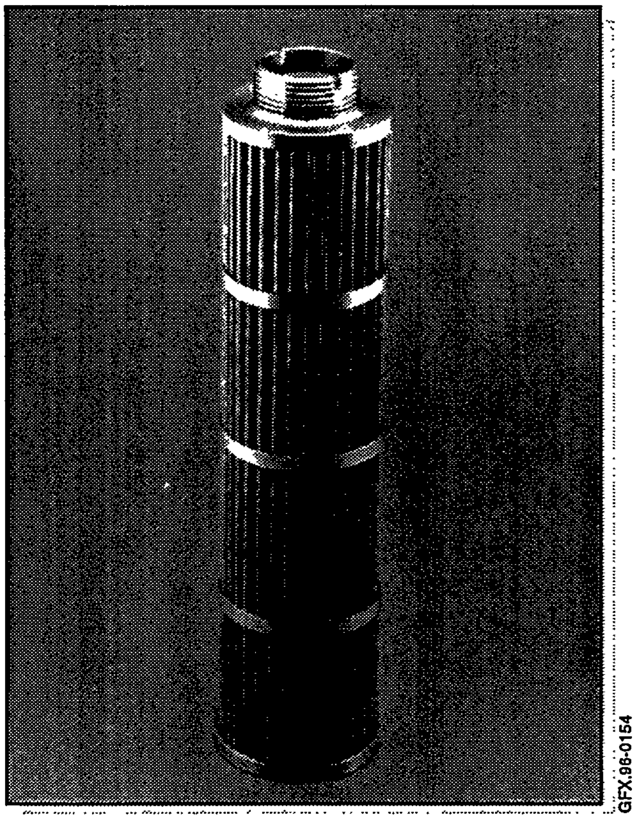

Figure 1.6-1. Stainless steel fibers are fused into a sheet and then formed into pleated cartridges.

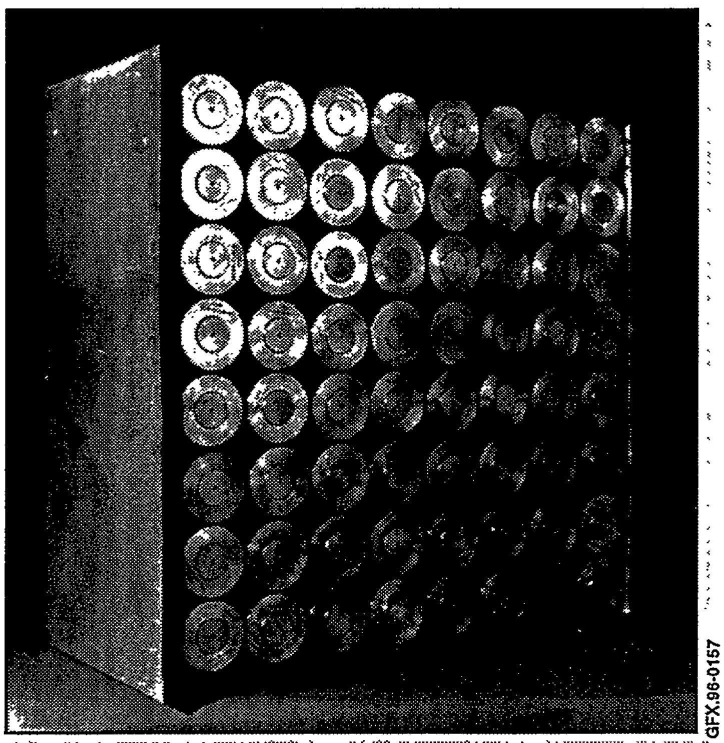

Figure 1.6-2. Sixty-four cartridge elements are packaged into a standard 2' x 2' x 1' frame.

are due to the material of construction. The filter uses filter media made from stainless steel fibers that are fused into a sheet and then formed into pleated cartridges, such as that shown in Figure 1.6-1. The cartridges are then packaged into the standard 2' x 2' x 1' frame, depicted in Figure 1.6-2.

The purpose of this task is to conduct a systems analysis to determine customer requirements for a cleanable steel HEPA filter, such as pressure drop, filter size, filter weight, and others. If the analysis shows that commercially available steel filters already meet customer requirements, then further development is not required. This work will identify what additional development or testing is required to meet the needs of the mixed waste users.

Benefits

Based on the current HEPA filter usage, replacing the current glass HEPA filter with cleanable steel HEPA filters potentially could save DOE $22 million each year. These savings will increase as the waste disposal costs increase. An additional benefit is the increased safety due to a much higher strength steel filter compared to the fragile glass paper filter. The current glass paper filter may fail when it gets wet, hot, or overpressured. In-place cleaning will also greatly reduce worker exposure to radiation. The cleanable steel HEPA filter will be applicable to all of DOE's mixed waste treatment processes that have an offgas emission. A major benefit of the cleanable steel HEPA filter to the mixed waste program is the significantly improved prospect for permitting the emerging treatment technologies by ensuring better worker and environmental protection.

Collaboration/Technology Transfer

This task will not involve technology transfer because it includes only a survey of mixed waste facilities, commercially available steel filters, and a systems analysis of the mixed waste operations to establish requirements for the steel filters. If the results from this task indicate that further development of the cleanable steel filter is required, then PALL Corporation has indicated that it will participate in a CRADA with LLNL. PALL has already signed a letter of intent.

Accomplishments

- LLNL has reviewed potential applications of the cleanable steel HEPA filter in existing and future mixed waste treatment systems at INEL, Hanford, Savannah River, and LLNL.

TTP Information

Cleanable Steel HEPA Filter technology development activities are funded under the following technical task plan (TTP):

TTP No. SF2-6-MW-36, "Cleanable Steel HEPA"

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2.0 SLUDGES AND SOILS

The waste streams addressed by this product line comprise approximately 46.8 percent of the mixed waste inventory. Wastes that fall into this category are at least 50 percent by volume inorganic sludges, including water content. Sludges are generally considered to be unstable solids, and have total suspended solids (TSS) greater than 30 percent. Inorganic particulates, paints, and salt wastes are included in this waste type.

The technologies developed in this product line focus primarily on producing an acceptable final waste form from mainly inorganic mixed waste streams. Several approaches to producing final waste forms for disposal are being developed simultaneously to allow the maximum number of waste streams to be treated. In addition, the technologies developed in this product line will be capable of stabilizing residues produced by other mixed waste treatment technologies. Examples include the vitrification of ash produced by the Toxic Substance Control Act (TSCA) incinerator at Oak Ridge and offgas treatment residues.

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2.1 TRANSPORTABLE VITRIFICATION SYSTEM FOR MIXED WASTE PROCESSING TECHNOLOGY DEVELOPMENT

TECHNOLOGY NEEDS

The goal of the Transportable Vitrification System (TVS) technology is to demonstrate effective treatment of approximately 75 percent of the mixed waste in inventory for safe land disposal. The TVS, believed to be the first of its kind in the world, is a fully integrated system for the preparation and vitrification of mixed waste. It is capable of performing vitrification demonstrations or treating small to medium waste streams, with considerable attention to operations with radioactive materials.

TECHNOLOGY DESCRIPTION

The stabilization and disposal of mixed wastes, which contain both hazardous and radioactive materials, is a significant waste management challenge to the DOE. The vitrification process, when properly designed and executed, produces a waste form that is highly stable and leach resistant. Recently, DOE laboratories have studied the application of the vitrification technology to the stabilization of low-level and mixed wastes resulting from nuclear materials processing activities in the DOE complex over the last 50 years. A large portion of these wastes have been shown to be suitable for treatment by vitrification through laboratory and small-scale melter demonstration on both surrogate and actual wastes. The DOE Office of Science and Technology tasked the Westinghouse Savannah River Company (WSRC) at Savannah River Site (SRS) to develop a larger scale vitrification technology for a field-scale demonstration on actual mixed waste at a DOE facility.

The TVS, as depicted in Figure 2.1-1, was designed to treat low-level and mixed wastes in the form of soils, waste water treatment sludges, incinerator ash, and similar material. The unit is a large-scale, fully integrated, vitrification system and is designed to be transportable and easily decontaminated. While primarily intended for waste demonstration activities, the TVS is large enough to completely treat small to medium-sized (up to approximately 500,000 kg) waste streams. The equipment is housed in modules that can be disassembled into containers and sealed for shipment on standard trailers (approximately 15 trailers required). Major modules include feed preparation, melter, offgas, control and services, and process laboratory. Slurried or dry feed is introduced to the feed preparation module where it is blended with glass formers. A slurry system then pumps the waste/additives mixture to the melter. The melter module contains a joule-heated, cold-top melter manufactured by EnVitCo, Inc. of Toledo, Ohio. The melter is refractory lined with a separate chamber for

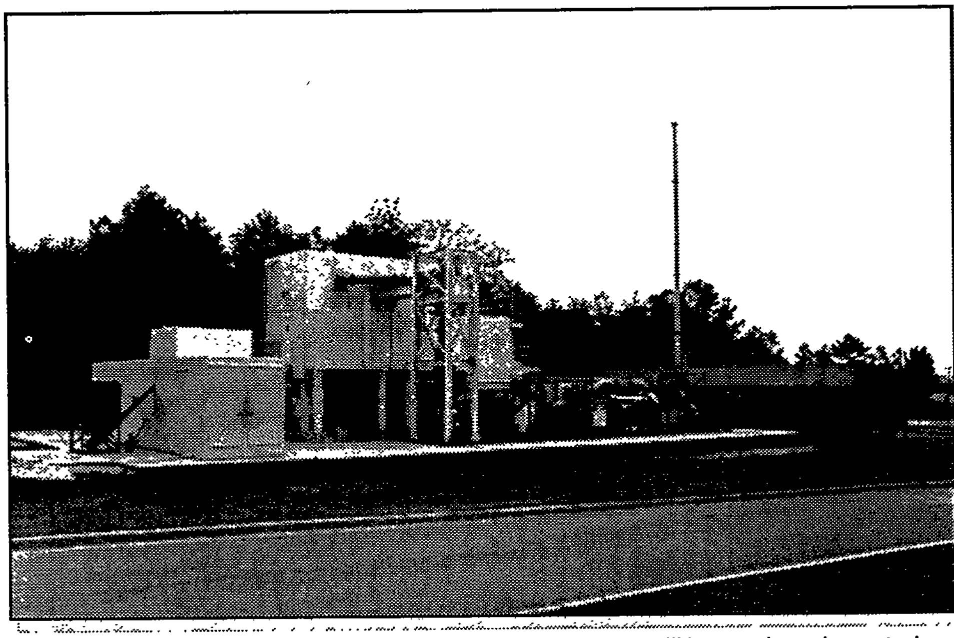

Figure 2.1-1. The transportable melter vitrification demonstration will be conducted on actual mixed waste.

the glass drain. Offgas is processed in a separate emissions control module. The offgas treatment sub-system was procured from Anderson 2000. The glass product is continuously poured into steel containers which, after cooling, are stored for eventual disposal. Site preparation requirements for the TVS are kept to a minimum. Once the system is re-assembled, it contains all the equipment required to perform vitrification, including a process control laboratory assembled by Calumet Coach.

TVS shakedown testing on a nonradioactive surrogate of the actual waste to be treated was successfully performed at Clemson University's Environmental Systems Engineering Department, producing approximately 25,000 pounds of simulated waste glass.

The field-scale demonstration for the TVS will be performed at the K-25 site in Oak Ridge, Tennessee (operated by Lockheed Martin Energy Systems) in FY96. The primary waste streams are B&C Pond sludge and Central Neutralization Facility (CNF) sludge. CNF treats liquid effluent from the mixed waste incinerator, the K-25 Site steam plant, a metal cleaning facility, and various small quantity or infrequent streams. The process uses a hydrated lime slurry to neutralize the effluent and precipitate metals. The sludge is classified as mixed low-level waste (MLLW).

Benefits

The successful production of a nonleachable glass waste form from MLLW will allow the land disposal of the waste at a lower cost than if the baseline technology (cementation) was used to stabilize the waste. The cost saving is due primarily to the large volume reductions realized during vitrification. In addition, glass final waste forms have been shown to have decreased leachability and increased structural stability over the baseline waste form.

COLLABORATION/TECHNOLOGY TRANSFER

The TVS Project is a collaboration among SRS, Clemson University (which operates the DOE Vitrification Research Center), ORNL, and private companies that are providing equipment and technical support. The project is being supported by the DOE Office of Science and Technology (EM-50) and the DOE Office of Waste Management (EM-30).

ACCOMPLISHMENTS

- The Savannah River Site teamed with EM-50 and Clemson University to create the DOE Vitrification Research Center, which has logged many hours of pilot-scale operation with the EnVitCo cold-top melter system.
- Clemson University was selected for the site of the shakedown testing because of their extensive experience with a similar EnVitCo melter at the DOE Vitrification Research Center.
- Scoping tests were performed at Clemson using the EnVitCo melter on surrogate B&C Pond sludge. The data from these tests will be used to determine important operational parameters during the actual waste demonstration.
- Preparation of the Technology Demonstration Area was completed at the K-25 Site, the planned location for the TVS.
- Permit applications for conducting the demonstration have been submitted to state and federal regulators.

TTP INFORMATION

Transportable Vitrification System for Mixed Waste Processing Technology Development activities are funded under the following technical task plans (TTPs):

TTP No. SR1-6-MW-41, "Transportable Vitrification System at ORR"

TTP No. OR1-6-MW-43, "Mixed Waste Destruction of Sludges and Soil"

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2.2 VITRIFY-TO-DISPOSE TECHNOLOGY DEVELOPMENT

TECHNOLOGY NEEDS

The goal of the vitrify-to-dispose approach to waste stabilization is to provide treatment capability for approximately 75 percent of the mixed waste inventory. A radioactive demonstration of the vitrification of the Oak Ridge B&C Pond sludge in a fully transportable, complete melter system is scheduled for FY96 and will help accomplish this goal. However, treatment of troublesome components such as mercury and organics has to be demonstrated before the technology can be applied to the target of 75 percent of the waste.

TECHNOLOGY DESCRIPTION

The purpose of this project is to enhance and further develop the "Treat to Dispose" vitrification technology. Vitrification involves converting wastes that are primarily inorganic in nature into glass, typically inside a Joule-heated melter. This is accomplished by carefully choosing additives to react chemically with potential glass-formers within the waste. The result is a high waste loading glass with increased final waste-form homogeneity and decreased leachability.

Emphasis has been placed on broadening the number of waste streams applicable to vitrification by establishing the processing envelopes for specific representative waste streams and specific hazardous components. Five specific wastewater treatment sludges (Oak Ridge Y-12 WETF sludge, LANL TA-50 sludge, Rocky Flats precipitate sludge, SRS M-Area sludge, and Oak Ridge K-25 B&C Pond sludge), ash streams, SRS soil, resin, and wastes with high mercury and organic components have been identified for treatment. Processing envelopes have also been identified which incorporate the major components of typical MLLW. When using these envelopes, the glass composition is based on the waste composition and the additives needed to stay within the processing envelope.

The study is also investigating advanced glass-making processes utilizing the expertise and pilot-scale resources at Clemson University. Two state-of-the-art, joule-heated, slurry or dry fed glass melters are available at the Clemson University Environmental Systems Engineering Department - DOE/Industrial Laboratory for Vitrification Research. One is a cold-top design with high temperature capability (1500°C) manufactured by EnVitCo, and the other is a stirred melter which is limited to about 1050°C, manufactured by Stir-Melter. See Figures 2.2-1 and 2.2-2. The environmental impact of the glass making process (e.g., air emissions), as well as the environmental impact of the finished product, are evaluated at this laboratory. Data derived from this work can be used to formulate a delisting plan that will be used to establish vitrification as an acceptable technology for the delisting of MLLW.

The culmination of the melter development work is a field-scale radioactive demonstration of vitrification technology that was initiated in FY95. The demonstration will utilize a fully integrated system including material handling, glass melting, offgas treatment, and process control subsystems, all of which will be transportable in nature. The demonstration using the TVS to treat actual waste has been scheduled to begin in FY96 with Oak Ridge K-25 being the host site. The actual mixed waste stream selected for treatment is the Oak Ridge K-25 B&C Pond Sludge.

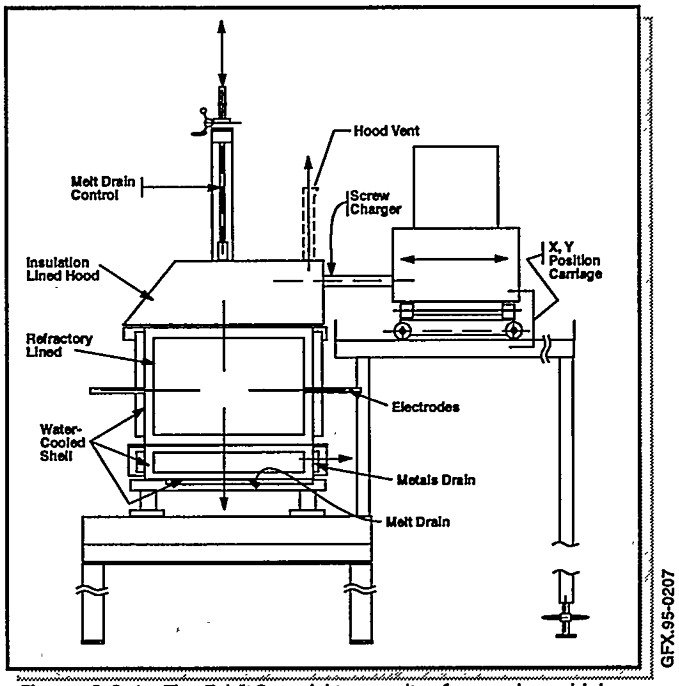

Figure 2.2-1. The EnVitCo cold top melter furnace has a high temperature capability (1500°C).

BENEFITS

The successful production of a non-leachable glass waste form from MLLW will allow the land disposal of the waste at a lower cost than if the baseline technology (cementation) were used to stabilize the waste. This cost savings is due primarily to the large volume reductions realized during vitrification as opposed to the small volume reductions (or even volume increases) resulting from grouting or cementation. In addition, glass final waste forms have been shown to have

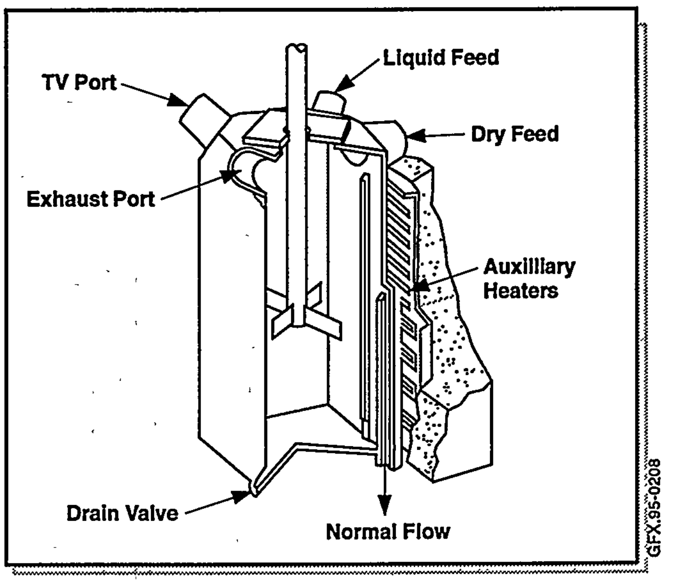

Figure 2.2-2. The Stir-Melter furnace is limited to about 1050°C.

decreased leachability and increased structural stability when compared to the baseline waste form.

Collaboration/Technology Transfer

This project is a collaboration among SRS, Clemson University (which operates the DOE/Industrial Laboratory for Vitrification Research), Oak Ridge National Laboratory (ORNL), Oak Ridge Reservation, and private companies that are providing equipment and technical support. EnVitCo, Inc. has a high waste loading, transportable melter. The Clemson Technical Center is providing chemical analysis service, waste form characterization, and engineering support for the pilot-scale demonstrations with actual waste. SRS is contributing its expertise on how the glass should be made. This project has been supported by EM-50, SRS's High-level Waste Program, the Savannah River Economic Development Program, and the DOE Office of Waste Management. Current support is from the EM-50 Mixed Waste Focus Area and EM-30 of the Oak Ridge Reservation.

Accomplishments

- The SRS has teamed with EM-50 and Clemson University to create the DOE/Industrial Laboratory for Vitrification Research. The laboratory has completed its third year of operation and has logged over 3,000 hours of pilot-scale operation with the Stir-Melter system and over 6,000 hours operating the EnVitCo cold-top melter system.
- The Transportable Vitrification System has been constructed and is undergoing field testing with surrogate Oak Ridge B&C Pond sludge. EnVitCo supplied the melter and also integrated the system. The offgas treatment sub-system was procured from Anderson 2000, and the transportable process control/analytical trailer is being assembled by Calumet Coach.
- Crucible-scale studies with K-25 B&C Pond sludge have been performed at Oak Ridge. The soda-lime-silica (Na_2O-CaO-SiO_2) glass system was chosen for this waste. Waste loadings of up to 50 percent have been achieved with actual wastes. Scoping tests were performed at Clemson using the EnVitCo melter, which is similar to that which will be used in TVS. The scoping tests using surrogate B&C Pond sludge will determine important operational parameters to be used during the actual TVS demonstration. A pilot-scale demonstration with actual B&C Pond waste will be performed in the EnVitCo melter currently located at the Clemson Technical Center.

TTP Information

Vitrify-To-Dispose Technology Development activities are funded under the following technical task plans (TTPs):

TTP No. SR1-6-MW-42, "Vitrification Process Limits Testing and High Temperature Demonstration on Actual Waste"

TTP No. SR1-6-MW-41, "Transportable Vitrification System at ORR"

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2.3 PHOSPHATE BONDED CERAMIC FINAL WASTE FORMS

TECHNOLOGY NEEDS

For many waste streams, vitrification is not technically feasible because of interference from problematic species or high cost. An example would be a waste stream for which some constituent has a low solubility in the glass melt, resulting in a lower-than-acceptable waste loading. Also, the presence of highly volatile contaminants and pyrophorics in a waste stream makes it very difficult to stabilize these wastes with currently available technologies.

Alternative waste stabilization processes are needed to allow the Mixed Waste Focus Area to meet its goal of demonstrating at least three technologies in the next three years that cumulatively will have the capability of treating at least 90 percent of the mixed waste in DOE's current inventory.

TECHNOLOGY DESCRIPTION

The purpose of this project is to exploit the attractive features of chemically bonded phosphate ceramics (CBPCs) and develop superior waste forms for MLLW streams that cannot be handled by other established methods. Guidelines and assessments will be set up on the basis of the waste stream with the best treatability performance, and that stream will be scaled up for pilot study (see Figure 2.3-1). Typical MLLWs contain liquid mercury, mercury-

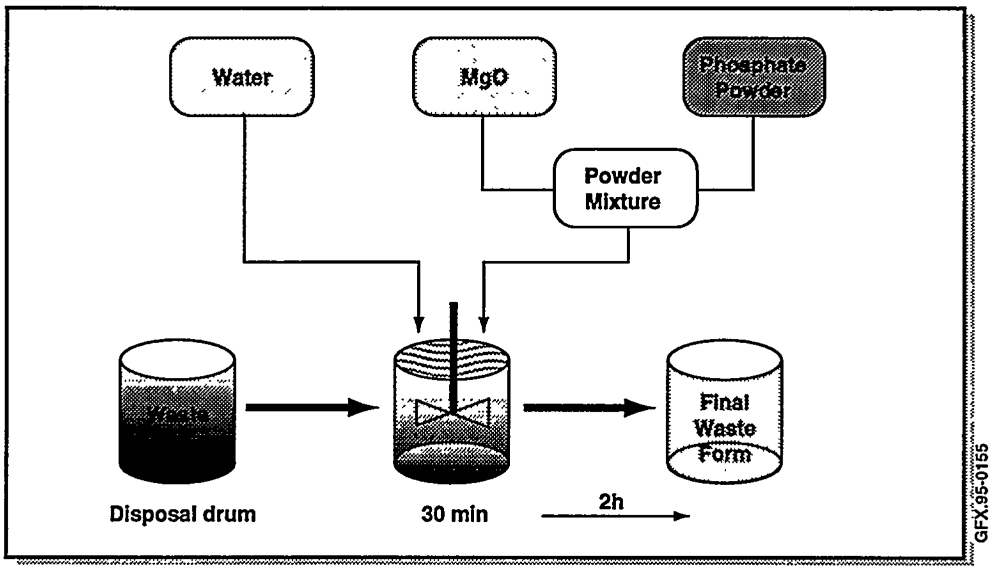

Figure 2.3-1. Phosphate bonded ceramic material and waste form development will be scaled up for pilot study.

contaminated aqueous liquids, toxic and heavy-metal-containing materials, salt cakes and processing salts, ashes, or pyrophorics.

CBPC technology has several advantages over other systems for stabilization and encapsulation:

- Phosphates are natural analogs of radioactive and rare earth elements.
- They are extremely insoluble.
- Phosphates can be processed in ceramic form at room temperature.
- CBPCs are nonflammable and thus present no danger of fire during transportation and storage.
- There is minimum generation of secondary waste streams.
- Due to low-temperature synthesis of the final waste form, there is no risk of volatilization, fabrication steps are minimal, and contamination of equipment during fabrication is low.
- Overall processing costs are low.

Calcined MgO and zirconium hydroxide can be reacted with a phosphoric acid solution or acid phosphates to form a stable ceramic form. The reactions occur at room temperature to form a dense ceramic that sets into a hard product in approximately 2 hrs. Surrogate ash waste streams, salt compositions, and cemented sludge were incorporated into phosphate ceramics with loadings of more than 50 percent. These waste streams were spiked with RCRA metal nitrates (Cd, Cr, Ni, Pb, Hg, Cs). Toxic characteristic leaching procedure (TCLP) tests were then used to evaluate the performance of the final waste form. Using radioactive surrogates, we have shown that these ceramic waste forms immobilize radioactive contaminants extremely well.

Long term leaching studies employing ANSI 16.1 have shown the superior long-term durability of the final waste form. Bench-scale studies have been scaled up to treat waste streams in volumes of several gallons.

BENEFITS

CBPCs have the potential for stabilizing several problematic mixed-waste streams that have been identified by DOE. These include mercury-contaminated wastes, salt wastes, and ashes. The CBPC process is very attractive for stabilization and solidification of these waste streams at room temperature. The waste forms are pore-free, insoluble in ground water, and nonleachable even in a geological time scale. They form solid solutions with actinides and rare earths. This method of stabilization can be exploited to incorporate various components of the mixed waste into solid monolithic ceramic form.

COLLABORATION/TECHNOLOGY TRANSFER

This work was performed in collaboration with the Center for Advanced Cement-Based Materials at the University of Illinois at Urbana-Champaign. Argonne National Laboratory has applied for patents on the process. Currently, the technology is being transferred to Delphi Research, Inc. of Albuquerque, New Mexico, to apply this technology for stabilization of several DOE waste streams.

ACCOMPLISHMENTS

Magnesium phosphate ceramics have been produced with the following properties:

- The ceramics set at room temperature into a dense, hard matrix at controllable set rates.
- Ash loadings (e.g., from incinerators) up to 70 wt. percent can be incorporated.
- Up to 0.5 wt. percent of Hg, Cd, Cr, Ni, or Pb can be incorporated into the ceramic and it will still pass the Environmental Protection Agency (EPA) TCLP test.
- The ceramic products have compressive strengths of up to 9,000 psi.
- Studies with surrogates of plutonium and uranium have demonstrated that these radioactive contaminants can be stabilized with negligible leaching levels (barely detectable by the most sensitive instruments) in water.
- Tests have demonstrated that zirconium phosphate ceramic can capture cesium chloride up to 1 wt. percent without leaching in water.
- A batch process has been developed to treat several gallons of solids, liquids, or sludges at one time.

TTP INFORMATION

Phosphate Bonded Ceramic Final Waste Forms technology development activities are funded under the following technical task plan (TTP):

TTP No. CH2-4-MW-44, "Phosphate Bonded Ceramic Final Waste Forms"

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2.4 POLYMER MICROENCAPSULATION

TECHNOLOGY NEEDS

Rocky Flats has several low-level mixed waste streams containing high concentrations of salts (primarily chlorides, nitrates, sulfates, and fluorides). These wastes need to be stabilized to meet Environmental Protection Agency, Department of Transportation, and disposal site requirements prior to shallow land burial. The need to stabilize low-level mixed salts to meet regulatory requirements is a problem that is common to many DOE sites throughout the complex. Over the last several years, Rocky Flats has demonstrated that encapsulation of high salt and ash wastes in a polymer matrix produces durable, leach resistant waste forms with relatively high waste loadings (30 to 80 percent).

Scale-up tests using actual low-level mixed wastes are being conducted at Rocky Flats under Research, Development, and Demonstration permits. Completing this pilot-scale demonstration on actual low-level mixed soluble salt waste addresses the largest volume currently generated waste at the site as well as the complex-wide problem of soluble salt mixed waste.

TECHNOLOGY DESCRIPTION

The U.S. Department of Energy has supported over the past 12 years the development of polymer encapsulation technologies for treatment of low-level radioactive, hazardous, and mixed wastes. Tests completed to date using both surrogate and actual waste indicate that polymer microencapsulation is a viable treatment option for a variety of mixed waste streams, including evaporator concentrate salts, sludges, incinerator ash, ion exchange resins, blowdown solutions, and molten salt oxidation residuals. Furthermore, polymers have been successfully used to macroencapuslate radioactive lead and debris wastes. This discussion emphasizes polymer microencapsulation applications.

Mixed waste stabilization using polymers is adopted from existing processes widely used in the polymer industry. Although the application of polymers to mixed wastes differs from private sector applications in the areas of product acceptance criteria and operating conditions, the two applications are very similar. Two classes of polymers, thermosetting and thermoplastic, have been applied to waste encapsulation.

Thermoplastic polymers such as polyethylene (a commonly-used plastic that is resistant to chemicals and moisture) are combined with dried waste in a commercially available twin screw extruder, which melts the polyethylene and mixes it with the waste. The waste encapsulated in polyethylene is extruded into a drum, where it solidifies upon cooling. The process operates at a low temperature, requires no offgas treatment, and generates no secondary waste. Since high loadings of waste may be incorporated into the polymer, a substantial reduction in volume may be possible relative to cementation, which is the baseline technology.

Thermoset polymers, such as epoxies, are formed by the chemical reaction of a liquid monomer and a curing agent. Powdered waste is mixed with two components. As the liquid monomer and curing agent react, solidification occurs. Thermosetting polymers are a viable option for liquid waste solidification since they can be formulated in an almost endless variety of compositions to meet different requirements. A major disadvantage to using this process for stabilizing wastes is that waste constituents can react with the monomer and curing agent, thus interfering with solidification. Although thermoset polymers are a good option for macroencapsulation of debris and radioactive lead wastes, the potential for interference of the solidification reaction makes thermoset polymers a less desirable solution than thermoplastic extrusion for particulate wastes such as salts and sludges. For this reason, most of the emphasis for polymer encapsulation of mixed wastes within the DOE complex has been on thermoplastic extrusion using low density polyethylene.

BENEFITS

The successful development and implementation of polymer microencapsulation will benefit DOE's waste management efforts by enabling Rocky Flats and other sites to achieve compliance with the Resource Conservation and Recovery Act and thus meet the requirements of the Federal Facilities Compliance Act. The availability of this technology will enable the site to safely treat and ship large quantities of mixed waste.

Polymer encapsulation of mixed waste produces a superior waste form with less volume increase than conventional stabilization technologies. By reducing the number of processed drums required for storage, transport, and disposal, this technology has the potential for significant cost benefits compared to cementation. Other benefits of polymer encapsulation include the following: 1) it is an off-the-shelf technology, meaning that all components are readily available from various vendors; 2) the technology is relatively simple and straightforward, owing in part to its relative insensitivity to chemical changes in waste streams; 3) it is a nonthermal treatment process, so no secondary waste stream is generated; 4) decades of polymer processing experience by private industry are available to researchers within the DOE complex on both a consulting and a development basis; 5) it provides a market for recycled polymers; and 6) it has high public acceptance.

Collaboration/Technology Transfer

Polymer encapsulation development at Rocky Flats is being conducted with the collaboration of researchers at the Colorado School of Mines (CSM) and Rust Federal Services. CSM provides cost-effective support in the areas of characterization and process design. A Cooperative Research and Development Agreement has been established with Rust for demonstration and commercialization of the technology.

Ames Laboratory is developing an on-line process control system for the Rocky Flats salt waste. The technology is referred to as Transient Infrared Spectroscopy, and can measure the infrared emission spectrum of opaque material in a noncontact fashion. Ames Laboratory conducted a successful radioactive demonstration of the technology at Rocky Flats in 1995.

Accomplishments

- Completed treatability studies on nine low-level mixed waste streams
- Conducted full-scale tests on four low-level mixed waste streams
- Confirmed radioactive and thermal stability of polyethylene encapsulated low-level mixed salts
- Demonstrated use of recycled plastic for macroencapsulation

TTP Information

Polymer Microencapsulation technology development activities are funded under the following technical task plan (TTP):

TTP No. RF1-5-MW-49, "Polymer Encapsulation"

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3.0 SOLIDS/DEBRIS/SOILS

Solids/Debris/Soils is a waste type which includes those waste streams containing at least 50 percent (volume) debris which is defined under the Environmental Protection Agency's (EPA's) Resource Conservation and Recovery Act (RCRA) regulations as particle size greater than 60 mm and intended for disposal, or 50 percent soil, in which silt, rock, and gravel less than 60 mm are classified as debris. Debris accounts for approximately 44.5 percent of the total mixed waste inventory.

The technologies being developed in this product line have two main focuses: high-temperature processing via plasma technologies, and advanced organic removal and destruction technologies. One technology, the plasma arc fixed-hearth process (PHP), is capable of accepting a wide range of mixed waste streams, and can treat whole, unopened drums of waste. The robust nature of this technology results in a less comprehensive need for the characterization of the mixed waste streams prior to processing. The high cost of waste characterization could be dramatically reduced by the incorporation of this technology. A radioactive demonstration of the PHP at bench-scale is scheduled for FY96.

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3.1 Plasma Hearth Process Development

Technology Needs

Many waste streams under the responsibility of DOE are heterogeneous and, as a result of the conditions under which the waste streams were historically generated, are poorly characterized. Detailed characterization of these wastes would incur significant costs. DOE needs technologies that can treat wastes, meet permit requirements, and satisfy process monitoring needs with minimal waste stream characterization and segregation or pretreatment requirements. Further, treatment technologies are needed that dramatically reduce waste volumes and produce final waste forms that will be accepted by a final waste disposal site. The Plasma Hearth Process (PHP) provides a relatively near-term solution to these technology needs. Plasma arc technology has been in industrial use for many years for metal ore smelting, metal and refractory production and recycling, and metal cutting and welding. Plasma arc thermal treatment units are commercially available for treating nonradioactive industrial and municipal wastes. The PHP MLLW treatment development project represents a low-risk modification and application of a proven technology to DOE's unique low-level radiological and hazardous waste stream processing requirements.

Technology Description

The fixed hearth plasma arc thermal treatment unit uses a direct current (DC) arc plasma transferred torch generated in a gas flowing between two electrodes. The term "plasma" refers to a highly ionized electrically conductive gas. Plasmas can be generated by a variety of techniques, over a wide range of pressures and energy levels. The type of plasma produced in the PHP application is a DC arc-generated thermal plasma and is created by a device known as a "plasma torch." The plasma torch used in the PHP operates in the transferred arc mode. See Figure 3.1-1.

The transferred arc torch uses a flow of gas to stabilize an electrical discharge (arc) between a high voltage electrode (inside the torch) and a molten pool of waste (maintained at ground potential). Because of the very high resistance to electrical current flow through a gas, electrical energy is converted to heat. Additionally, energy is converted as the electric current passes through the melt, creating a Joule-heating effect in the molten pool.

Processing begins as complete drums of waste are fed to the plasma chamber, where heat from the plasma torch initiates a variety of chemical and physical changes. Complex organic compounds break down into noncomplex gases that are drawn from the chamber, while the remaining inorganic material melts and separates into two phases: slag and metal. Actinides and oxidized heavy

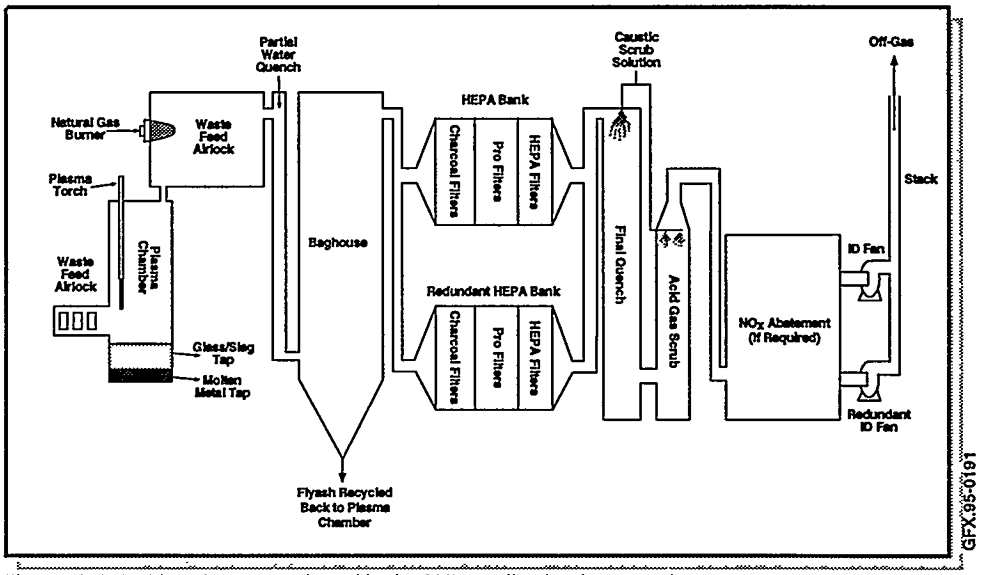

Figure 3.1-1. The plasma produced in the PHP application is created by a device known as a "plasma torch."

metals migrate to the slag phase which, after being removed, cools and solidifies into a glass-like, or vitrified, material. This high-integrity final waste form, similar to that selected for high-level radioactive wastes, has repeatedly shown the ability to meet or exceed disposal requirements instituted by the RCRA.

PHP thermal treatment technology is characterized by high-efficiency destruction of organics, encapsulation of heavy metals and radionuclides in the vitrified final waste matrix, maximum reduction of waste volume, low offgas rates, and the capability of processing many waste types in a single-step process.

The PHP program has been established to develop, test, and evaluate a new concept for treating mixed waste. The program is split into nonradioactive and radioactive activities. The nonradioactive testing involves two separate PHP research systems. The first system, a proof-of-principle system, is a simplified version of the PHP concept that was designed and built in 1992. The system operates in a batch mode and has the capacity to process two 30-gallon drums per batch. Testing on the proof-of-principle system was completed in FY94. The second system is a pilot-scale PHP system which is a follow-on to the proof-of-principle system. The pilot-scale system is being designed to be a more complete version of the PHP concept. While it is being called a "pilot-scale" project, the hardware being designed and tested is essentially full-scale in size. This will lower the technology performance risk when implementing a large-scale hardware of the field-scale system.

The second activity is comprised of a radioactive bench-scale unit, which will be built and tested in parallel with the nonradioactive pilot-scale unit. The bench-scale will be a batch process, capable of feeding up to eight 1-gallon cans of material per test. The plasma chamber is designed to closely model the pilot-scale plasma chamber so that comparisons of radionuclide/surrogate behavior can be obtained. Installed at the Argonne National Laboratory-West

(ANL-W) Transient Reactor Test (TREAT) facility, the unit has a 200 kw torch and a throughput of two 1-gallon cans per hour.

Under PHP technology development, representative surrogate waste streams will be treated to determine the applicability of the technology and any unique processing requirements. Surrogates will not initially contain radionuclide components. Partitioning of radionuclide surrogates will be determined, and a design for a second generation plasma hearth furnace that will safely treat mixed low-level (radioactive) wastes will be developed and tested. Waste stream characteristics required for processing will be determined. The project staff will work with regulatory entities to determine the minimal characterization parameters required to meet regulatory requirements while ensuring process safety and effectiveness. Representative final (vitrified and metal) waste forms produced by the process will be evaluated for their performance with respect to leachability, mechanical strength, integrity, and other parameters as determined under the project.

The radioactive bench-scale PHP system design, construction, and installation in the ANL-W TREAT facility will be completed in FY96, with radioactive testing to begin in the fourth quarter of FY96. The pilot-scale nonradioactive PHP system will be constructed at Retech, Inc. in Ukiah, CA, with testing to begin in late FY96.

BENEFITS

The PHP has potential in a wide range of applications to vitrify a variety of mixed wastes currently stored at sites throughout the DOE complex. Features that make the PHP particularly attractive include: the ability of the process to accept whole drums of waste; little or no special front-end handling requirements, feed preparation, or pretreatment; reduced waste characterization requirements; the ability to destroy organic compounds, including hazardous organics; partitioning of the transuranic (TRU) components to the slag phase; and a stable, nonleaching end-product that complies fully with all RCRA regulations.

COLLABORATION/TECHNOLOGY TRANSFER

This program is a collaboration between Lockheed Idaho Technologies Company (LITCO), ANL-W, SAIC, and Retech, Inc. Patent rights are being investigated and both SAIC and Retech are interested in commercialization of the technology as appropriate. Retech is supplying the plasma torch equipment and the melter chamber. In addition, Science Applications International Corporation (SAIC) operates a 200 KW nonradioactive system at its Science and Technology Applications Research (STAR) Center in Idaho.

ACCOMPLISHMENTS

- Completed title design of the melter, offgas system, and TREAT modifications
- Developed surrogate material recipes for simulating Idaho National Engineering Laboratory (INEL) mixed wastes in initial surrogate and spiked-radionuclide tests
- Specified radioactive spike sources to include plutonium, uranium, and cesium
- Completed fabrication and installed complete melter system
- Completed design, procurement, and installation of the bench-scale secondary chamber and air pollution control system
- Generated Final Safety Analysis Report to confirm the adequate safety of the system's design and operation
- Received approval of an application for a National Emission Standards for Hazardous Air Pollutants permit
- Received approval for RCRA Treatability Study for planned actual waste tests
- Issued bench-scale system design description
- Prepared system operating and maintenance and checkout procedures
- Prepared training plans and procedures
- Initiated packaging (or repackaging) of test materials and wastes into bench-scale 1-gallon cans
- Participated in such forums as Western Governors' Association Demonstration On-Site Implementation Team, Tribal and Public Forum on Technology Acceptance, and met with officials from the Idaho state government

TTP INFORMATION

Plasma Hearth Process Development technology development activities are funded under the following technical task plans (TTPs):

TTP No. CH2-3-MW-56, "PHP-Radioactive Demonstration Project"
TTP No. ID0-3-MW-50, "PHP Radioactive Demonstration Project"
TTP No. ID7-4-MW-51, "PHP-Pilot-scale Testing"

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"Feed Material Handling and Waste Disposition Plan for the Radioactive Bench-Scale Plasma Hearth Process System," SAIC-94/1159 (May 1995).

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"Results of STAR Center Testing in Support of the Radioactive Plasma Hearth Process System," SAIC-96/1004 (February 1996).

3.2 PROCESS MONITORING AND CONTROL

TECHNOLOGY NEEDS

The elemental composition of the slag end-product is essential in determining the optimum operating parameters of the plasma hearth treatment process. The elemental composition of the slag will in part determine: 1) the operating temperature of the system to maintain the slag in a nonviscous state for processing, 2) the durability of the slag, 3) the leaching properties of the slag, and 4) the degree of actinide loading. Chemical analysis will play a major role in determining the degree of partitioning of Pu, U and their surrogates in the slag, particulate, and metal phases produced from the process. If the PHP is to be a continuous process with limited characterization of the input feed, then the elemental composition of the slag, the degree of metal loading, and the effect on the leaching characteristics of the slag waste form must be determined continuously. Use of the diagnostic and control technology described below can ensure that the end-product of the process, namely slag, falls within well defined compositional boundaries where the behavior of the product is well understood. This ensures that the process can operate in a consistent manner, as designed, and reduces the costs of analytical characterization to dispose of the end-products.

TECHNOLOGY DESCRIPTION

The continuation of this project during FY96 will emphasize the testing and development of diagnostic and control technologies on plasma hearth treatment systems for low-level and TRU mixed wastes. Though the projects are directed to the PHP, the diagnostic and control technologies are applicable to thermal waste processing technologies being developed across the DOE complex. The primary tasks/objectives of the FY96 project include the following activities:

A. Elemental analysis using x-ray fluorescence (XRF) on vitreous slag and particulate obtained from the radioactive plasma hearth bench-scale demonstration will be performed. PHP slag and particulate samples will be analyzed using the XRF techniques to determine the content of structural elements, RCRA metals and actinides. The goal is to reduce analysis costs, sample analysis turn-around time and, if warranted, maintain a compositional envelope for the slag. Ultimately, the technique may be used to assess the elemental composition of the slag end-products produced from production-scale facilities.

B. With the aid of DIAL at Mississippi State University, remote Fourier Transform Infrared (FTIR) measurements will be performed to determine the molecular compositions of offgases produced by the radioactive bench-scale unit. Emissions from the combustion of trichloroethylene, dichlorobenzene and byproducts such as CO, HCl and NO will be measured. The analytical capabilities of the above system will be characterized and evaluated with respect to detecting offgas emissions below those required for offgas system optimization. Cross correlation techniques will be evaluated for providing "operator friendly" process information.

C. The performance of an extractive FTIR cell for monitoring volatile organic compounds (VOCs) produced by the plasma processing will be demonstrated. The real-time calibration and detection of gaseous VOCs will also be demonstrated, and the information will be used to support the development of the offgas system for larger scale plasma systems.

BENEFITS

The development of the XRF technique for the analysis of slag samples has provided and will provide data that are comparable to those provided by extensive wet chemical Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES) analysis. However, the XRF technique will reduce sample preparation and analysis time from days to a matter of hours. Furthermore, the technique does not generate the copious quantities of liquid waste produced by ICP analysis techniques. This technology will provide significant cost savings to the development of plasma hearth treatment systems by reducing analysis costs and delays while awaiting analysis results. The development of the in situ and extractive infrared techniques with real time signal processing can be used for optimization of offgas processing parameters as well as to alert operators of off-normal processing conditions. Again, the number of costly analyses will be reduced or eliminated using in situ real-time process offgas monitors.

COLLABORATION/TECHNOLOGY TRANSFER

The XRF technique is applicable for the on-line quantification of hazardous metals and can be applied to many commercial plasma technologies.

ACCOMPLISHMENTS

- A wavelength dispersive x-ray fluorescence unit was installed in a Pu glovebox in the A-wing of the analytical laboratories. The preliminary evaluation of the XRF technique for the analysis of Ce in the PHP slag was performed. The initial results were in good agreement with wet chemical analysis. A series of 48 powdered standards were prepared to perform analyses of Al, Mg, Si, Fe, Pb, Ni, Cr, Cd, Ce, and U in PHP slag.

- Two FTIR based offgas monitors have been evaluated for the detection of vapor phase molecular compounds. The first is an in situ FTIR monitor which is used to monitor simple combustion end-products. The second is an extractive FTIR system which is used to measure VOCs. A collaborative effort between the DIAL and ANL-W was initiated to determine whether an in situ FTIR and a slip stream extraction, multiple reflection long-path cell are suitable for remote offgas monitoring of radioactive gas streams.
- A collaborative effort between ANL and DIAL continued in evaluation laser induced breakdown spectroscopy (LIBS) for the detection of actinides entrained in the PHP offgas system. LIBS measurements were made in an alpha glovebox at ANL-W. Qualitative spectra from PU, U, and Np were obtained. An optical interface for remote operation of the LIBS system was designed and constructed. Remote data collection routines are being developed.
- An integrated data collection and data processing system was designed and constructed at ANL-W. A SUN workstation was interfaced to numerous PCs for remote automated data collection from two FTIR spectrometers, a nondispersive HC1 detector and the LIBS systems.

TTP Information

Process Monitoring and Control technology development activities are funded under the following technical task plan (TTP):

TTP No. CH2-4-MW-54, "Process Monitoring and Control"

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3.3 SUPERCRITICAL CARBON DIOXIDE EXTRACTION

TECHNOLOGY NEEDS

Large quantities of low-level solid mixed wastes such as rags, coveralls, paper, plastics, and surgeon's gloves contaminated with radionuclides, oils, greases, and hazardous solvents have been generated at nuclear weapons manufacturing sites across the DOE complex. As long as the hazardous solvents are present, these wastes are considered land disposal restricted and cannot be disposed of at any site in the country. Supercritical carbon dioxide extraction (SCDE) offers a proven solution to this problem, because it can extract the hazardous solvents from the waste substrates leaving a land-disposable low-level waste.

SCDE is ready for pilot-scale demonstration in the treatment of low-level solid mixed wastes and will meet the implementation schedule of the Rocky Flats Site Treatment Plan. A 16-gallon commercial unit has been procured for an FY96 and FY97 mixed waste demonstration (See Figure 3.3-1). This system is production scale for Rocky Flats requirements and could be used to treat the entire range of SCDE-applicable waste streams.

SCDE will be further developed for the removal of hazardous metals and radionuclides using chelating agents. The Universities of Idaho and Syracuse have patents on the use of chelating agents for the removal of heavy metals and believe the removal of radionuclides using similar agents can be achieved.

TECHNOLOGY DESCRIPTION

SCDE is a process that employs a flowing, noncombustible, nontoxic, environmentally safe fluid as a solvent. This process takes advantage of the enhanced ability of carbon dioxide to dissolve organic contaminants once it has been heated and compressed above 90°F and 1,080 psi. In waste cleanup applications, SCDE is used to dissolve the hazardous components and extract them from the substrate material. By lowering the temperature and pressure at the expansion vessel, the contaminants fall out of solution allowing separation and recycling of the carbon dioxide (See Figure 3.3-1). This process is capable of producing a dry residual waste form that can be treated as radioactive, rather than mixed waste. Because the system operates at high pressure, it is run in a batch mode and is completely sealed.

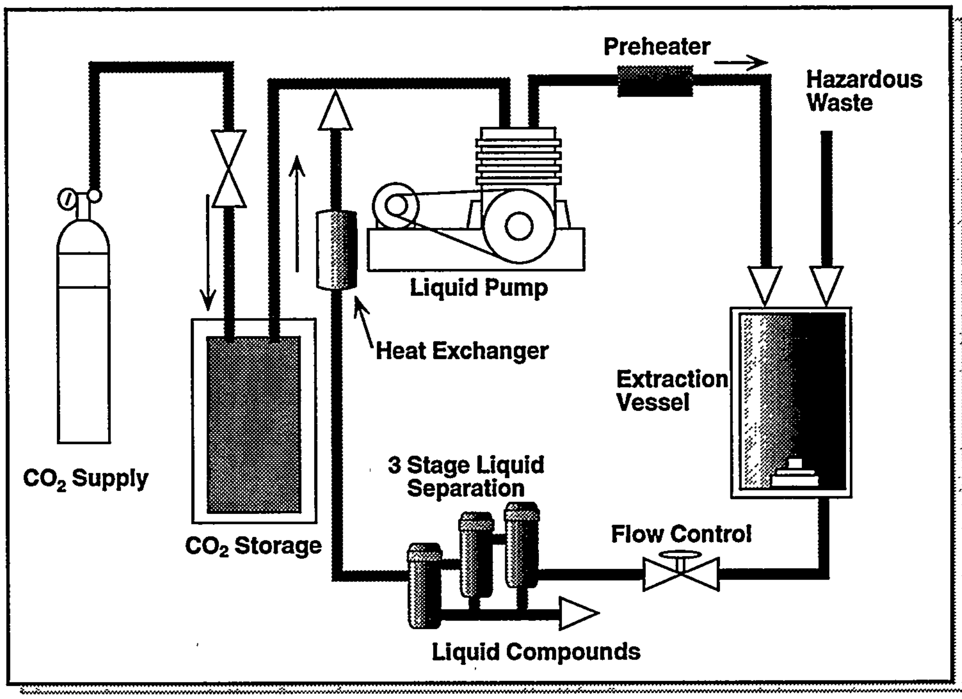

Figure 3.3-1. The SCDE process takes advantage of the enhanced ability of carbon dioxide to dissolve organic contaminants once it has been heated and compressed.

BENEFITS

Successful development and implementation of organic removal technologies could remove selected waste streams from land disposal restrictions status. Removal of hazardous solvents from TRU mixed and mixed low-level wastes (MLLW) would simplify disposal of treated waste forms and result in cost savings. SCDE employs a noncombustible, nontoxic, environmentally safe fluid as the solvent. Information and results obtained in this project support the SCDE project described in Section 3.4.

COLLABORATION/TECHNOLOGY TRANSFER

Studies of SCDE at Rocky Flats are being conducted in collaboration with the University of Colorado Cooperative Institute for Research in Environmental Sciences. Since SCDE equipment is commercially available, commercial partnering has focused on companies interested in utilizing this technology as part of their commercial waste treatment business. CF Systems, Inc. has been selected as the industrial partner for a Cooperative Research and Development Agreement (CRADA) involving the demonstration and implementation of supercritical carbon dioxide extraction at Rocky Flats. For the development of the removal of hazardous metals and radionuclides using chelating agents, Rocky Flats will work with the University of Colorado and the University of Idaho.

Accomplishments

- Laboratory-scale testing of SCDE for the removal of hazardous volatile and semi-volatile compounds from a variety of solid waste substrate materials has been completed at the University of Colorado.
- Experimentation has shown that the process will extract volatile and semi-volatile organic compounds, including PCB's, to extraction efficiencies over 99 percent in a 20-minute cycle time. These extraction efficiencies and cycle times can also be scaled to larger scale production systems.

TTP Information

Supercritical Carbon Dioxide Extraction technology development activities are funded under the following technical task plan (TTP):

TTP No. RF1-5-MW-58, "Supercritical Carbon Dioxide Extraction"

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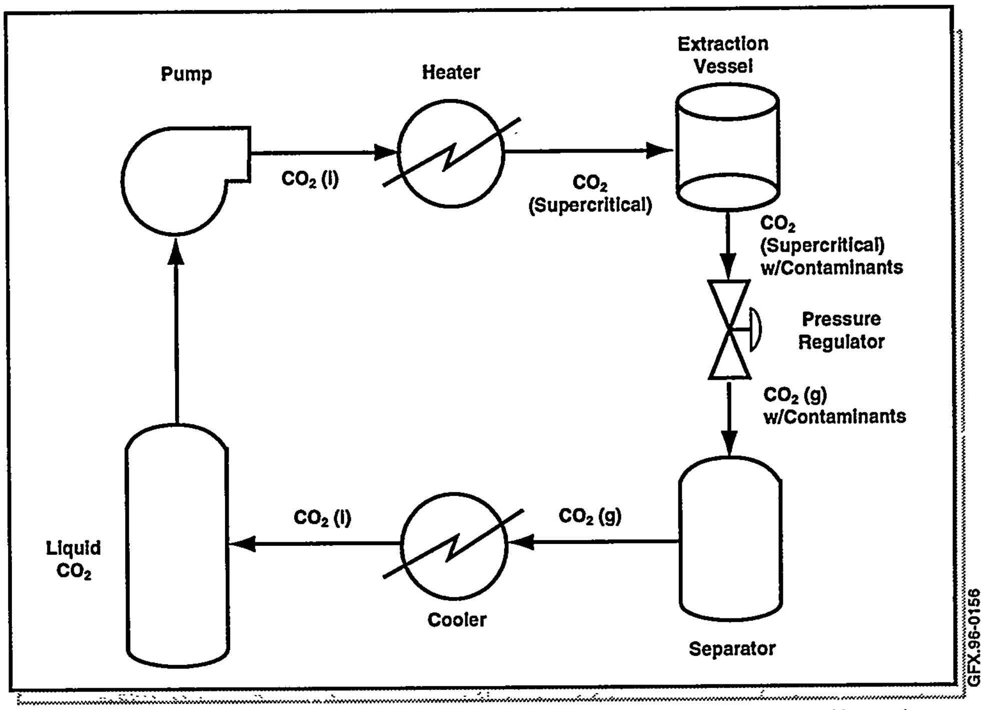

Figure 3.4-1. In supercritical carbon dioxide extraction, liquid CO_2 is pressurized and heated to supercritical conditions.

described in Section 3.3, to acquire and establish the appropriate equipment and facilities for the demonstration of extraction, to report on the level of success of demonstration compared to expectations, and to provide recommendations for implementation of this process at DOE-Hanford.

BENEFITS

The benefits to be derived from this work are primarily upon solid streams although they are also applicable to liquid streams. Supercritical fluid extraction is broadly seen to provide significant cost reduction because of minimal treatment of the solvent to provide recycling (e.g. gaseous separation and cooling) and the small cost of most solvents (e.g. CO_2).

COLLABORATION/TECHNOLOGY TRANSFER

DOE has been involved with the sponsorship of precision cleaning research and development, and commercialization, since 1991. Currently, environmental remediation agents and academia are involved with studies and deployment of supercritical carbon dioxide extraction to address site cleanup wastes. An industrial partner will be considered following large-scale mixed waste treatment.

Accomplishments

- This TTP was initiated in FY96. Funding to date has been $50K. Pending receipt of additional funding, this TTP may continue.
- Westinghouse Hanford Company (WHC) researched collaborative mechanisms between Hanford and Rocky Flats which may streamline the development and application of supercritical carbon dioxide extraction for complex-wide needs and may encourage resource and information sharing between Hanford, Rocky Flats, and other DOE sites and private industry.
- WHC issued a report (see Hendrickson et al., 1995 in bibliography) to describe the Hanford and Rocky Flats collaborative mechanisms.

TTP Information

Extractive Organic Pretreatment of Solid Radioactively Contaminated Waste technology development activities are funded under the following technical task plan (TTP):

TTP No. RL4-6-MW-59, "Extractive Organic Pretreatment of Solid Radioactively Contaminated Waste"

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4.0 Unique Wastes

Unique Wastes include lead shielding, other elemental heavy metals, batteries, fluorescent light bulbs, explosives and propellants, compressed gases, lab packs, and other miscellaneous wastes that present unique treatment problems and are not included in the previously defined categories. They also include the Final Waste Form and Unknown/Other Category wastes, and Z and U series waste streams identified in the *Department Of Energy Waste Treatability Group Guidance* document (DOE/LLW-217 January 1995). Unique Wastes represent approximately 3.7 percent of the DOE mixed waste inventory.

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4.1 MACROENCAPSULATION OF MIXED WASTE

TECHNOLOGY NEEDS

Polyethylene is an inert, low permeability, thermoplastic material that is highly resistant to chemical attack, microbial degradation and radiation damage. These properties combine to provide an extremely durable and stable final waste form for the disposal of DOE and commercial waste streams. Original development efforts focused on microencapsulation of wastes in which the waste is combined with molten plastic in an extruder to form a homogeneous mixture and is then cooled to form a monolithic solid waste form. More recently, however, the process has been applied to macroencapsulation, in which larger pieces of waste not suitable for extrusion processing (e.g. lead, debris) are surrounded by a layer of clean polyethylene to isolate the contaminants from the environment. The Environmental Protection Agency (EPA) has identified polymer macroencapsulation as the Best Demonstrated Available Technology for radioactive lead soils and mixed waste debris, defined as materials exceeding 60 mm in particle size.

According to the materials in inventory report published September 29, 1995, the current lead waste inventory throughout the DOE complex is estimated to be between 17 million kg and 24 million kg. Decontamination of at least a portion of lead is viable but at a substantial cost. Because of various problems with decontamination and its limited applicability, and no available treatment and disposal method, the current practice is indefinite storage, which is costly and in many cases not acceptable to the regulators

TECHNOLOGY DESCRIPTION

This task supports a cooperative agreement between DOE's Idaho Operations Office and Envirocare of Utah, Inc. In that agreement, a macroencapsulative technology developed by DOE at the Brookhaven National Laboratory (BNL) will be transferred to a commercial enterprise and demonstrated for the treatment and disposal of selected mixed radioactive-hazardous wastes from other DOE facilities.

The polyethylene macroencapsulation process utilizes a single-screw plastics extruder to melt, convey, and pump molten polyethylene through a die and into a waste form container. A schematic diagram of an extruder is shown in Figure 4.1-1. The extruder consists of an auger-type screw enclosed in a barrel to which polyethylene, typically in the form of beads, is gravimetrically fed from a storage hopper resting above the feed throat. The polyethylene is gradually heated and melted as it is conveyed by the screw through independently

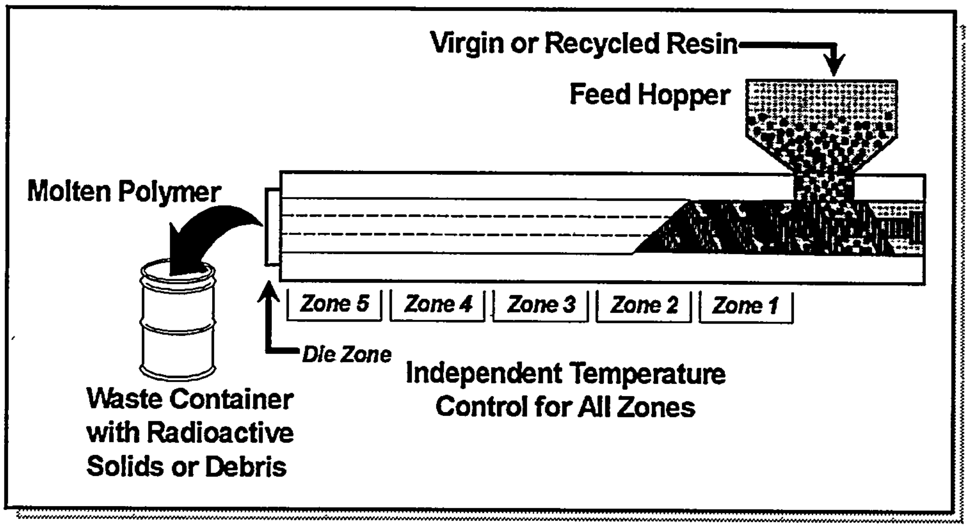

Figure 4.1-1. A single screw extruder pumps molten polyethylene through a die and into a waste form container.

controlled temperature zones. The heat for melting the polyethylene is provided through the heaters and by frictional heat which is generated by a gradual decrease in the screw channel depth between flights along the screw. Temperatures are set to achieve a uniform molten output flow. The required processing temperatures are dependent on the type and grade of resin used. Recycled resins may be used in this process, providing a valuable new end-use for industrial and post-consumer solid waste plastics.

As shown in Figure 4.1-2, the molten polyethylene from the extruder die is poured into a waste container in which waste materials have either been suspended or supported. Techniques for generating uniform macroencapsulated waste form products depend on desired waste form geometry, extruder/die configuration, processing conditions, and type of resin used. Figure 4.1-2 shows a waste form container that utilizes an interior cage-like basket to hold the waste requiring solidification.

BENEFITS

Benefits of the cooperative agreement between DOE and Envirocare of Utah, Inc. are as follows: 1) technology developed by DOE will be transferred to private industry for commercial use; 2) treatment and disposal of mixed radioactive-hazardous wastes using macroencapsulation technology will be demonstrated; 3) inventories of mixed radioactive-hazardous wastes stored at several federal installations will be reduced; and 4) large quantities of mixed radioactive-hazardous wastes stored at other federal installations can be treated and disposed of in upcoming years.

In addition, technologies will provide improved waste form performance and result in reduced risk to human health and the environment. Polyethylene

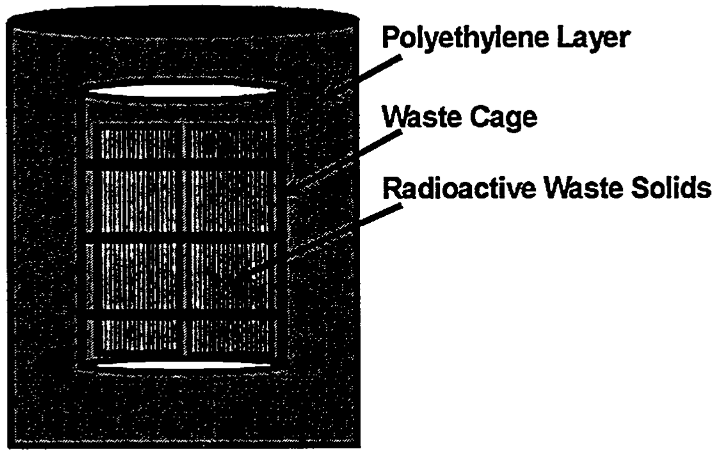

Figure 4.1-2. Molten polyethylene is poured into a container in which waste materials have been suspended or supported.

macroencapsulation of nitrate salt waste compared favorably with Portland cement grout solidification, both technically and economically. For example, use of polyethylene at Rocky Flats was estimated to result in up to 70 percent fewer waste drums for storage, transport, and disposal, resulting in annual net costs savings between $1.5 and $2.7 million.

The Tank Focus Area has estimated cost savings of $200 million over the life of the single shell tanks remediation project at Hanford based on using this process. Similarly, modified sulfur cement and polymer-impregnated concrete can accommodate high-waste loadings, and thus reduce overall costs.

COLLABORATION/TECHNOLOGY TRANSFER

Polymer solidification development at the Rocky Flats Environmental Technology Site (RFETS) is being conducted with the collaboration of researchers at the Colorado School of Mines and WHC. Drying and extrudability studies are also being performed by several equipment vendors. Investigators at Brookhaven National Laboratory are also participating in the development of this technology in conjunction with Envirocare of Utah, Inc. and Scientific Ecology Group.

Transfer of polymeric encapsulative technology to Envirocare of Utah, Inc. expands capabilities and broadens disposal options provided by commercial enterprise. It also enlarges the mix of strategies available to DOE for the management of other types of mixed radioactive-hazardous wastes. The cooperative agreement realized equal fiscal contributions from both parties.

The following sites are shipping radioactive contaminated Pb and potentially other mixed waste to Envirocare for treatment using the macroencapsulation technology developed by EM-50 under the cooperative agreement: Argonne National Laboratory-East, Battelle-Columbus at Ohio, BNL, Fernald, Formerly Utilized Sites Remedial Action Program, INEL, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Lawrence Berkeley Laboratory, Nevada Test Site, Oak Ridge National Laboratory, Paducah, Pantex, Pinellas, Portsmouth, Richland, Savannah River Site, Oakland sites (Energy Technology Engineering Center, Laboratory for Energy-Related Health Research, Stanford Linear Accelerator Center, and General Atomics). Two Navy sites (Bettis Atomic Power Laboratory and Mare Island) are also participating in this cooperative agreement.

ACCOMPLISHMENTS

- DOE has signed an agreement with Envirocare of Utah, Inc. to demonstrate the macroencapsulation process on a commercial scale by disposing of 500,000 pounds of contaminated lead from the Idaho National Engineering Laboratory (INEL). The process will be treating waste at approximately 1 1/2 tons of lead per day.
- The macroencapsulation process has been successfully transferred to the private sector and is now available as an independent commercial capability. Macroencapsulation has become an attractive option to industry and government by stabilizing contaminated waste and providing a way to recycle plastic.

TTP INFORMATION

Polyethylene Macroencapsulation technology development activities are funded under the following technical task plan (TTP):

TTP No. RF1-5-MW-49, "Polymer Encapsulation"

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4.2 RADIOACTIVE POLYCHLORINATED BIPHENYL WASTE TREATMENT DEMONSTRATION

TECHNOLOGY NEEDS

Polychlorinated biphenyl (PCB) contaminated radioactive waste is currently being stored at several DOE facilities. Waste of this type has been in storage at the Savannah River Site for over 15 years. Due to the capacity limitation of the Oak Ridge Toxic Substances Control Act Incinerator (TSCAI), solids contaminated with PCBs and radioactivity will remain in storage for another 10 years, minimally. Demonstration of the VAC*TRAX™ process will provide an option to continue storage by minimizing risks associated with postponing final treatment.

TECHNOLOGY DESCRIPTION

This task demonstrates and evaluates an innovative technology for treatment of solid radioactively contaminated PCB waste. The approach involves sampling and analysis of typical PCB contaminated solid waste. Evaluation of various solvents and waste preparation methods was carried out in the laboratory using simulated nonradioactive materials. Laboratory testing has also been carried out with representative radioactive waste samples. The VAC*TRAX™ process was found to be most suitable for treating the radioactive-PCB porous solid waste. The treatability permit from EPA Region IV was modified to reflect that information. Pilot-scale testing of the VAC*TRAX™ process will be carried out to evaluate the efficiency of PCB separation/extraction and the suitability of the process for treating radioactive-PCB contaminated solid, soil-like waste.

If the process is demonstrated to provide acceptable treatment for PCB contaminated solid material, then actual radioactive PCB contaminated absorbent material will be tested on the pilot-scale.

BENEFITS

By demonstrating and evaluating the VAC*TRAX™ process, low-level waste contaminated with PCBs will be reduced, and a waste treatment option that shortens the storage time will be enhanced. A process that potentially treats a low-level PCB contaminated waste will also provide a timely, cost-effective treatment option to DOE generators across the complex.

Collaboration/Technology Transfer

The Savannah River Site and Clemson Technical Center, Inc. will conduct this treatability demonstration together. The Clemson Technical Center recently received a Toxic Substance Control Act permit from EPA Region IV to perform PCB treatability studies using the VAC*TRAX™ process. The Clemson Technical Center also has a permit for handling radioactivity. Complementing the Clemson attributes, the Savannah River Site has the capability of disposing of all low-level radioactive waste which may be generated as residue during this testing and demonstration. Additionally, the Clemson Technical Center has taken the lead in investigating marketing opportunities for treating soils contaminated with PCBs.

Accomplishments

- Initial VAC*TRAX™ runs were made, and several metal objects were decontaminated and assessed for free release.

TTP Information

Radioactive Polychlorinated Biphenyl Waste Treatment Demonstration technology development activities are funded under the following technical task plan (TTP):

TTP No. SR1-6-MW-65, "Radioactive PCB Waste Treatment Demonstration"

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Hoeffner, S.L. and C.A. Langton. "Characterization of Nine Drums Containing PCB-Rad Materials," WSRC-RP-96-214, Prepared for WSRC, Subcontract No. AB62435T (February 1996).

4.3 DRUM INSPECTION ROBOTICS APPLICATION

TECHNOLOGY NEEDS

Drum inventories are growing at many DOE sites, thus increasing costs, the labor required, and worker radiation dose associated with inspections intended to prevent leaks. Currently each of three drum inspection robot systems supported by DOE are at the bench-scale level of performance. With improvements that all three programs have planned for FY96 and early FY97, each should be at the pilot-scale level by the time for a three-way comparison, or "bake-off." These systems generally consist of a mobile robotics base that is capable of self-navigation, coupled to sensor suites collecting visual and range images of each drum. The images are then analyzed so that rust, dents, streaks, blisters, and tilting conditions can be detected. Through early detection of these corrosion cues, the threat of material release is mitigated. Worker exposure and labor is also reduced, and warehouse management improvements are made possible. The Resource Conservation and Recovery Act (RCRA), which mandates weekly inspection of stored mixed waste, is the driver for these systems. RCRA storage facilities and the need for robotics technology are found across the DOE complex.

TECHNOLOGY DESCRIPTION

Drum inspection robots address the need for drum and facility inspections by visually inspecting drums and other aspects of the facility and inventory. This project includes the testing, evaluation, downselection, and final integration of the following drum inspection robots:

- The Intelligent Mobile Sensing System (IMSS) built at Denver, Colorado, by Lockheed-Martin Aerospace. IMSS recently finished a demonstration in a mock-up cold test pit.

- The Autonomous Robotics Inspection Experimental System (ARIES) built by the South Carolina Universities Research and Education Foundation completed a demonstration in November 1995.

- The Stored Waste Autonomous Mobile Inspector (SWAMI) created by Savannah River Technology Center and Lawrence Livermore National Laboratories (LLNL) has been tested in an informal "technology evaluation" at Fernald.

Additionally, a separate image analysis system entitled "Automated Baseline Change Detection" (ABCD) will be evaluated in conjunction with one or more of the mobile robots. It is being built at Palo Alto, California, by Lockheed-

Martin Missiles and Space. The challenge is to identify the best elements of each system, and select the subcomponents and vendors to be involved in integration of a final system, should none be found to be commercially-ready during the bake-off. Selection will depend on relative demand for the technology, waste inventory size, and the site's ability and willingness to host a demonstration. Developmental testing sessions, in which the IMSS and ARIES robots will gain five weeks experience in an actual drum warehouse at Fernald, have now been set for late April through July 1996. The actual bake-off has been delayed until early 1997 so that all development teams can complete currently defined technical scope before the final comparison.

BENEFITS

Drum inspections will significantly reduce demands on human inspectors, especially as inventory increases. They will also support the DOE objective of as-low-as-reasonably-achievable through the reduction of radiation exposure for drums containing gamma-emitting substances. Drum inspection robots will be consistently diligent in inspections of the containers, and will provide timestamped, unalterable documentation of inspection activities and drum condition archiving images. The robots' images will subsequently be linked to an on-line record for each container for ease of future retrieval. It will also be possible to identify containers that deteriorate more quickly and, by merging previously captured images to form a history of one container's degradation, trends will be established that can help predict the likelihood of future deterioration.

COLLABORATION/TECHNOLOGY TRANSFER

The projects participating in the bake-off have industrial partners already involved. In the case of IMSS and ABCD, the developers are commercial entities which are willing and able to develop additional units. The ARIES robot is being built with a team that includes a private industry partner, who will have access to the technology after the demonstration. This provides a clear and logical path to providing additional units or spare parts as the market for them develops. In the case of SWAMI, Transitions Research Corporation is supplying the HelpMate base vehicle and has the capability to provide an industrial-grade version of SWAMI in the future.

ACCOMPLISHMENTS

Work to date has focused on:

- Producing a draft of the bake-off brochure
- Identifying possible sites to participate in the program

- Providing access to Fernald's facilities for developmental testing
- Completing a paper for Waste Management '96 describing the drum inspection application and this project
- Holding knowledge engineering sessions in which technical teams interviewed Fernald's inspectors to improve their system's classification of corrosion features
- Forming a user's group which will serve as an advisory board throughout the project; it will provide guidance on desired functionality and test plan elements to select the bake-off site and provide feedback to developers

TTP Information

Drum Inspection Robotics Application technology development activities are funded under the following technical task plan (TTP):

TTP No. OH1-6-MW-64, "Drum Inspection Robotics Application"

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Hazen, F.B. and R.D. Warner. *Proceedings of Waste Management '96* (February 1996).

5.0 TREATMENT SYSTEM TECHNOLOGIES

Treatment System Technologies are not waste types; rather, they are technologies which support the primary treatment systems under development within the Mixed Waste Focus Area (MWFA). Emphasis is placed on characterization of waste feed materials and effluents, process control, and effluent characterization using flow-through, real-time continuous monitors, advanced offgas treatment techniques, and a system for offgas capture, measurement, and release.

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5.1 CAPTURE AND RELEASE OFFGAS SYSTEM

TECHNOLOGY NEEDS

Public concerns about uncontrolled releases from thermal treatment systems have had a significant impact on the permitting and operation of these systems. The MWFA is addressing these concerns through the Controlled Emissions Demonstration, which is based on the premise that all effluent from the plasma processing system can be captured, separated, analyzed for contaminants of concern, and then either released or recycled to the process.

TECHNOLOGY DESCRIPTION

This project will install and demonstrate several technologies to capture and separate various components of the offgas emitted from a plasma incineration system. The main purpose of the demonstration is to determine if the technologies can be used in a system that will minimize process input streams and allow recycling of the majority of the incineration gases, thus minimizing offgas emission to the atmosphere. An ancillary purpose of the demonstration is to determine if the existing gas phase analytical instrumentation can detect very low concentrations of hazardous components in the offgas, with the ultimate purpose of using them as sensors in a process control system. Chief among these constituents are vapor phase metals, such as mercury and polychlorinated aromatic hydrocarbons.

Work to be performed in this task will include performance testing of the slip stream high temperature PALL filter and the THERMATRIX Flameless Oxidizer, and upsizing of the high temperature filter and flameless oxidizer, plasma torch, or O_2 enriched natural gas burner. If performance testing on the filter and oxidizer slip loop components is deemed successful, the following will be installed and tested:

- A scrubber blowdown water treatment system
- The Pulsatron, Inc. electrical corona discharge scrubber
- A volatile organic constituent monitor
- A metals continuous emissions monitor system
- A Russian NOx destruction catalytic NOx removal system
- A scrubber water roughing unit

Additionally, renewable HEPA filters will be installed in the slip loop in order to complete a demonstration on radioactive contaminated waste.

BENEFITS

The Plasma Incineration Controlled Emissions System demonstrates state-of-the-art process units at near full-scale process flow and composition, thus providing design basis and availability data to support a full-scale Mixed Waste Treatment Facility. Additionally, a test bed will become available that can provide steady state operation that will allow testing and demonstration of advanced analytical instrumentation capable of detecting part-per-trillion concentrations of contaminants of concern, which is needed for any closed loop system. Also, successful demonstration of the PALL filter and THERMATRIX flameless oxidizer at full scale will eliminate much of the particulate presently entering the wet scrubber, and thereby lower the overall volume of offgas by as much as 50 percent.

COLLABORATION/TECHNOLOGY TRANSFER

Several technology providers and analytical laboratories are involved in the Controlled Emissions Demonstration. These companies are THERMATRIX, PALL, Diagnostic Instrumentation and Analysis Laboratory (DIAL), Pulsatron, Inc., ADA Technologies, Inc., and Phoenix, Inc.

ACCOMPLISHMENTS

This project was started in the fall of 1994 by assembling a select group of people who are familiar with the DOE mixed waste needs and people who have expertise in incineration systems, offgas systems, plasma treatment systems, and instrumentation. Accomplishments include:

- A pragmatic approach to the development of a plasma offgas system was developed incorporating technologies that are mature and need little or no further engineering development. The initial planning effort was documented in a report titled, "Closed Loop Offgas Test Bed Order of Magnitude Estimate Design and Recommendations Report," dated November 8, 1994.
- During FY95, design, procurement and installation activities were started. Completed in FY96, they resulted in a quarter-scale test bed that will be used initially to demonstrate the PALL Ceramic filter and the THERMATRIX Flameless Oxidizer.

TTP INFORMATION

Capture and Release Offgas System technology development activities are funded under the following technical task plan (TTP):

TTP No. PE1-2-MW-71, "Controlled Emissions Demonstration"

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Battleson, D. "Status of the Department of Energy, Controlled Emissions Offgas Demonstration Project," International Conference, Seattle, Washington (May 8, 1995).

Battleson, D. "A Plasma Process Offgas Controlled Emissions Demonstration," International Symposium on Environmental Technologies, Atlanta, Georgia (October 9, 1995).

5.2 DEMONSTRATION OF EMERGING CONTINUOUS EMISSION MONITORING TECHNOLOGIES

TECHNOLOGY NEEDS

Several programs are being funded by DOE, the Environmental Protection Agency (EPA), and private industry to develop Continuous Emissions Monitor (CEM) technologies and systems. Continued advancement and future implementation of these technologies require pilot-scale demonstration in actual process environments. Information gained in the demonstrations at the EPA Incineration Research Facility (IRF) will assist in identifying the current state of the art by demonstrating selected emerging technologies for continuous emissions monitoring of hazardous and mixed waste thermal treatment processes. This is desired for verification of emission compliance, process control, and public safety.

TECHNOLOGY DESCRIPTION

A CEM must perform continuous process sampling, while the analysis can be conducted in a batch operation. The batch analysis must be completed on site and be integral to the CEM. The CEM should provide a concentration value for the species of interest at least once every three hours. The response time (the time interval between the start of a step change in the system input and the time when the monitor output reaches 95 percent of the final value) of the CEM should be less than three hours. For CEMs utilizing batch analysis, the delay between the end of the sampling time and reporting of the sample analysis should be no greater than one hour. Also, there should be no greater than a 5-minute gap in sampling when the sample collection media is changed. Thus, a CEM should be able to continuously sample facility emissions, and have as close to real-time reporting of effluent concentrations as possible. In addition, the CEM must have detection limits low enough to ensure an ability to comply with the eventual regulatory limits for specific species of interest.

This program will identify promising emerging technologies for continuous monitoring of hazardous compounds in emissions from thermal treatment facilities. Species of particular interest include heavy metals, particulates, radionuclides, and organics. A series of technology demonstration tests are being performed at the EPA IRF, a pilot-scale rotary kiln incinerator. The program is intended to reveal potential advantages and disadvantages with each technology, and identify issues that could be encountered in a process environment.

Benefits

The information obtained in the demonstrations at IRF will be used to assist CEM technology developers in bringing their technology to the marketplace, to assist in finding end users for their products, and assist regulatory agencies in determining applicability of these technologies to future regulatory requirements.

Collaboration/Technology Transfer

This program is designed to assist the developers in advancing the state of the art of their technology and bringing each demonstrated CEM technology to the market place by assisting in the identification of end users for their product.

Accomplishments

- A team (10 members) of CEM experts representing DOE, EPA, and professional organizations [e.g. the American Society of Mechanical Engineers (ASME)] was assembled. This team developed a CEM demonstration test protocol. The test protocol consists of obtaining quantitative data on the four measures of CEM performance checked in a relative accuracy test audit as described in 40 CFR 60 Appendix F. These include relative accuracy, calibration drift, zero drift, and response time.
- A Memorandum of Understanding was prepared to combine this DOE program with an EPA CEM demonstration program. This joint effort effectively doubled the level of funding available for the program, allowing several additional CEMs to participate in the demonstration tests.
- Demonstration tests were conducted on 11 prototype CEMs for measuring trace metal or trace organic species concentration. Of the 11 CEMs tested, four measured concentrations of several specific volatile organic compounds (VOCs), one measured total particulate-bound polynuclear aromatic hydrocarbon concentrations, two measured concentrations of several (up to 14) hazardous air pollutant trace metals, and three measured mercury concentrations. A series of three test conditions were established for each monitor, each with varying quantities of trace metals and VOCs, to result in a low, medium, and high concentration of the target analyte. Each test series consisted of performing triplicate RM measurements at each of the three target flue gas analyte concentrations while the CEMs were in operation.
- A draft of the final test report was reviewed by all the CEM participants, the technical oversight committee, EPA, and WSRC.

TTP Information

Demonstration of Emerging Continuous Emission Monitoring Technologies development activities are funded under the following technical task plan (TTP):

TTP No. SR1-6-MW-72, "Emissions Monitor System Bakeoff"

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Bibliography of Key Publications

None available at this time.

5.3 PLASMA TORCH COMPONENT LIFE EXTENSION DEVELOPMENT

TECHNOLOGY NEEDS

The plasma torch is used as the source of heat to melt inorganic material and combust organic material. Previous testing performed at the DOE Western Environmental Technology Office (WETO) has demonstrated the capability of plasma torches to provide the heat source to melt any inorganic material and completely combust organic wastes. However, the same testing has revealed that current plasma torch designs have shortcomings due to their limited time to failure of components.

An improvement to the torch components is a logical extension of plasma technology development. A hybrid plasma torch design will permit the switching of the torch between the transferred mode and the nontransferred mode. The ability to operate in either arc generation mode will enable investigation into component life areas and into operational advantages of combined arc generation.

TECHNOLOGY DESCRIPTION

To enable the application of plasma technology to thermal treatment, the reliability of the torch component needs to be proven to DOE. WETO is in a position to evaluate different torch concepts and models from four different manufacturers (i.e. Perma, Busek, Phoenix, and Aerotherm) to help DOE focus on the most reliable type of torch and also to work with the manufacturers to increase electrode life and torch reliability.

Plasma torch component life extension will initially focus on the electrodes. The electrode is the anchor point for the electric arc, and is therefore subjected to high temperature induced stresses. The second phase of the investigation will be operation of the electric arc generation in the transferred and nontransferred modes. Component life will be evaluated for the two arc generation methods, as well as the ability to produce the necessary heat for melting and oxidation of waste materials. The final area of investigation will be with consumable electrode materials.

This project will prepare design objectives, provide for alternative selection, conduct testing, and prepare a final report containing recommendations on extending the life of the plasma torch components. In conjunction with the testing of the plasma torch components, the electrode materials and cooling schemes of the torch will be evaluated.

BENEFITS

For a production size plasma processing system, extension of plasma torch component life beyond the point of normal maintenance will be developed. An additional benefit will be evaluation of whether a nontransferred arc generation system and consumable electrode material provide significant increases in plasma torch component life.

The development of an alternative torch technology which will allow both transferred and nontransferred arc modes, as well as increased electrode life and system reliability, offers significant improvements in system flexibility and operability. It will also provide a torch capable of extended operation before initial components wear out or fail.

COLLABORATION/TECHNOLOGY TRANSFER

The purpose of this task is to provide a test bed for the evaluation of four different torch concepts developed by four private manufacturers: Perma, Busek, Phoenix, and Aerotherm. Results of the tests will assist manufacturers in increasing electrode life and plasma torch reliability. Testing of the Phoenix and Aerotherm torches are joint efforts between DOE and the Department of Defense (DOD). MSE, Inc. will assist in technology transfer activities as requested by the WETO DOE Program Manager.

ACCOMPLISHMENTS

This project was originally scheduled to begin in October 1995 and run through FY96. However, due to funding delays, official approval was not received until January 1996. The project schedule and spend plan were revised to accommodate the later start date. Accomplishments to date consist of the following:

- A subcontract has been issued to PERMA for technical assistance in improving their electrode life on the WETO/MSE Small-Scale Plasma Furnace (SSPF). The SSPF utilizes a PERMA 150 kw transferred arc torch.
- Existing operating data has been gathered on the PERMA torch at WETO and will be used as baseline data for future improvements.
- The MSE project manager is working directly with PERMA staff on torch component life improvements to be tested later.
- MSE has sent a procurement to the Pittsburgh Energy Technology Center for approval to purchase a BUSEK 150 kw torch. This torch is a transferred/ nontransferred arc, 150 kw torch which will be installed on the WETO/MSE SSPF in FY96 and tested in FY97.

- MSE is working directly with Busek staff on torch life improvements.
- An AEROTHERM hybrid torch has been purchased with funds from DOD and will be installed on the SSPF at WETO. Testing will be conducted using DOE funds from this project.
- A 500 kw PHOENIX nontransferred arc torch has been purchased with funding from DOD and will be installed on the WETO/MSE PACT-6 unit in the spring of 1996. Testing of the PHOENIX torch will be conducted in the summer of 1996 using funds from this project.

TTP Information

Plasma Torch Component Life Extension Development technology development activities are funded under the following technical task plan (TTP):

TTP No. PE1-6-MW-73, "Controlled Emissions for Component Demonstration"

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None available at this time.

5.4 Installation of Test Bed for Demonstrating Continuous Emission Monitors

Technology Needs

Innovators of new environmental technologies lack the infrastructure required to move their technology from innovation to the global marketplace. There is a need to strengthen the capacity of technology developers and users to succeed in environmental innovation. One area in which there is a need for technology development is in the area of instrumentation and methodologies for the monitoring of emissions from waste treatment processes. Of particular interest are thermal waste treatment processes. The Toxic Substances Control Act Incinerator (TSCAI) in Oak Ridge is the only operational mixed waste incinerator in the country that can process radioactively contaminated and polychlorinated biphenyl (PCB) waste. Thus, it provides the opportunity to monitor for a wide range of hazardous constituents under continuous operating conditions.

Technical Description

This task focuses on the definition and installation of a test bed for the evaluation of continuous emission monitors (CEMs) at the TSCAI. Since the TSCAI is a continuously operated, full-scale facility, the test bed will provide a unique means to conduct field tests of laboratory-proven CEMs in a real-world operating environment. After the test bed is established, it is anticipated that a minimum of four emerging CEM technologies will be demonstrated at the TSCAI test bed. The technologies will be subjected to various waste streams and offgas compositions within regulatorily compliant operation of the incinerator. Concurrent with the CEM demonstrations and testing, manual EPA reference method sampling and analysis will be performed for verification of the offgas composition. Particulate characterization by such techniques as energy dispersive x-rays spectroscopy may also be utilized to help verify the results from the CEM analysis. Procurement, construction, and installation of the test bed facility are anticipated to be completed in August 1996. Networking opportunities to promote participation and use of the facility are being pursued.

Benefits

The test bed will infuse quality into the most critical stage of technology – demonstration and evaluation. Through the consistent evaluation of the applicability of CEMs to DOE's and EPA's needs, technology developers will be able to provide the level and quality of monitoring support expected and demanded by the public sector.

Collaboration/Technology Transfer

This project is based upon collaborative efforts. The EPA Risk Reduction Engineering Laboratory and DOE Office of Science and Technology are currently collaborating on development of CEMs. DOE support is administered by the Education Resources Development Agency through the Georgia Institute of Technology under contract to DOE's Savannah River Technical Center. CEMs have been tested at EPA's Jefferson, Arkansas, Incineration Research Facility, a small-scale rotary kiln incinerator system test bed that cannot handle mixed waste. Also, ASME Research Committee on Industrial and Municipal Wastes has formed a subcommittee to specifically track progress in CEM development. These existing government and commercial partnerships will be utilized for the development and deployment of the next logical step, a national CEM test bed at the TSCAI.

The lessons learned and the performance characteristics of the CEMs tested will be shared with the technical and industrial community. It is hoped that this information will generate not only interest in the CEM technologies, but the continued support of CEM evaluation at the TSCAI test bed.

Accomplishments

- Technical requirements have been established for the design and installation of a mobile technology laboratory to accommodate health, safety, ergonomic, and quality requirements of CEM researchers and operations.
- Awareness has been gained for a number of ongoing CEM development activities involving technologies for monitoring metals, organics, and acid gases, in addition to known Mixed Waste Focus Area projects.

TTP Information

Installation of Test Bed for Demonstrating Continuous Emission Monitors technology development activities are funded under the following technical task plan (TTP):

TTP No. OR1-6-MW-74, "TSCA Test Bed for CEMs"

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Hoffmann, D.P., L.B. Gibson, Jr., W.H. Hermes, R.E. Bastian, and G.E. Frazier. "Guidelines for Benchmarking Thermal Treatment Systems for Low-Level Mixed Waste," DOE/MWIP-19, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee (January 1994).

Hoffmann, D.P., W.H. Hermes, L.V. Gibson, Jr., R.E. Bastian, and A.R. Eicher. "Data Quality Objectives: Evaluation of Thermal Treatment Processes," DOE/MWIP-22, Martin Marietta Energy Systems, Oak Ridge, Tennessee (March 1994).

Richards, M.K. et al. "Test Plan for Testing the Performance of Real-Time Incinerator Emission Monitors," U.S. Environmental Protection Agency, Risk Reduction Engineering Laboratory, Cincinnati, Ohio (April 1995).

5.5 MERCURY VAPOR REMOVAL AND CONTROL - GOLD AMALGAMATION FILTER

TECHNOLOGY NEEDS

Due to the toxicity of mercury and its bioaccumulation potential, severe regulatory limits are imposed on mercury emission under the Clean Air Act.

Mercury can be removed from wastes by pretreatment using chemical and/or thermal desorption techniques, but this is only cost-effective when relatively large amounts of mercury are involved. At lower levels, it is more practical to remove the mercury by offgas treatment. Chemical/physical methods are available to do this, including injection of activated carbon into the flue gas or removal by chemical scrubbing. Both of these techniques have a disadvantage in that secondary wastes are generated. Neither system responds well to high emission spikes due to variable waste composition.

TECHNOLOGY DESCRIPTION

The task is to develop and commercialize a system that removes vapor phase mercury emissions from the flue-gas streams of DOE mixed waste thermal treatment processes and industrial fossil fuel combustion. The mercury control technology relies on reversible sorption of mercury onto and into gold or other noble metals. Several tasks have been undertaken to develop this treatment process.

The first task was to develop a noble metal containing sorbents capable of regeneration. Once developed, the sorbents were incorporated into a full-scale prototype. A 50 cubic feet per minute (CFM) filter was built and integrated into the effluent stream at a DOE waste treatment facility to demonstrate mercury capture and release during repeated thermal regenerations.

The current task is to gather engineering design data by building and installing a prototype system that handles 50 to 100 CFM of offgas. This system will be operated for three or four "campaigns" of one calendar month duration each, at different DOE sites. During these runs, the flow rate and mercury concentration will be varied and the sorbent bed will be repeatedly regenerated. The information collected will be used to develop superior sorbents and to devise system scale-up rules in preparation for the proposed FY97 task. That task includes the installation and demonstration of a full-scale, 1,000 to 4,000 CFM, mercury control system at a DOE mixed waste treatment site.

BENEFITS

The major benefits of the gold-containing mercury sorbent process are the high loading capacities, high throughput rate, and the ability to regenerate and reuse the capture device. It captures all chemical forms of mercury, and operates in hot (up to 3,000°F), wet, and corrosive offgases typical of waste treatment systems. There are no secondary solid wastes.

COLLABORATION/TECHNOLOGY TRANSFER

ADA Technologies, Inc., Englewood, Colorado, in collaboration with Sandia National Laboratories, Livermore, California, is developing a technique for removing mercury from flue gas streams typical of thermal waste treatment processes.

ACCOMPLISHMENTS

- The Full-scale Prototype System was installed at the Science Applications International Corporation (SAIC) STAR Center in Idaho Falls, ID. A 50 CFM slip stream of 3,000°F flue gas with known concentrations of mercury flowed through the mercury sorption system. Gas samples were monitored at the outlet of the sorbent bed for a period of time and switched to the inlet. Inlet concentrations of mercury were in the tens of thousands of micrograms per cubic meter. Typical outlet concentrations were 30 to 40 micrograms per cubic meter. The removal efficiency was over 99 percent, and the sorbent beds were regenerated without a detectable loss in capture efficiency.
- The Continuous Mercury Monitor developed by Sandia National Laboratories and ADA Technologies, Inc. was demonstrated. It measures elemental mercury separately from total mercury (there may be several chemical forms of mercury in the offgas stream). The sorbent bed appeared to remove both elemental and speciated forms of mercury.

TTP INFORMATION

Mercury Vapor Removal and Control - Gold Amalgamation Filter technology development activities are funded under the following technical task plan (TTP):

TTP No. AL3-4-MW-75, "Mercury Vapor Removal and Control-Gold Amalgamation Filter"

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BIBLIOGRAPHY OF KEY PUBLICATIONS

None available at this time.

5.6 REAL-TIME MONITORING OF ALPHA EMISSIONS

TECHNOLOGY NEEDS

Monitoring for low-levels of airborne alpha-emitting radionuclides has long been a difficult and complex task. The short range and high rate of energy loss of alpha particles confound their easy detection and pose a significant health risk. Knowing, or at least fearing, the health risks associated with exposure to airborne radioactivity, and alpha-emitting particles in particular, the public has chosen to vigorously oppose the operation of existing, and the permitting of future, mixed and low-level waste treatment systems. The existing commercial monitors are based on the principle that a sample of stack gas is extracted, isokinetically transported, and passed through a filter that is surveyed by a detector. The Flow-Through Alpha Monitor (FTAM) is designed for real-time application, does not use filters or other high maintenance items, and the detector allows for a large active volume flow of stack gas. The sampling and long integration times of conventional detectors are necessary for the ultimate sensitivities required for regulatory compliance. The fast response, large active volume, and complete stack gas measurement of the FTAM technology is necessary to adequately provide real-time alarming.

TECHNOLOGY DESCRIPTION

The public is demanding real-time, high sensitivity, continuous monitoring of any facility or operation that can potentially release radionuclides to the environment. While the technology exists for long-term monitoring to ensure total emission compliance, most systems are poorly suited to monitoring at low-levels on a real-time, fast response basis.

A new real-time, continuous monitor for alpha emissions is being developed with Mixed Waste Focus Area funding. The FTAM uses a stack of scintillating plates sensitive to alpha decays, through which the entire gas stream to be measured flows. This detector is unique in that it can measure on-line, in real-time, a complete effluent stream without having to use sampling techniques or long measuring times. This technology provides a robust and fault-tolerant real-time safety monitor (i.e. a "smoke alarm") that can signal the need to shutdown a malfunctioning operation before the public is exposed to significant amounts of radioactive material. While the FTAM is designed for treatment system monitoring, it will be useful in any application where airborne alpha activity is possible. With the promise of providing the treatment site a comprehensive, fast responding, on-line alarm, the FTAM technology will soon establish the state of the art of incinerator monitoring for radioactive materials. The purpose of this project is to develop, test, and commercialize this new technology.

BENEFITS

The most direct and immediate benefit offered by the FTAM technology is to enable the operation of mixed, low-level, and TRU waste incinerators in a manner that is protective of workers and public health and safety. Additionally, this technology is important in monitoring alpha emissions for comparison to incinerator alternatives such as vitrification, plasma hearth, or supercritical extraction. The FTAM is ideally suited to take a large volume of moving air to credibly monitor a large scale remediation demonstration or activity. The FTAM, with a few modifications, can provide real-time, on-line monitoring for building ventilation, mine ventilation, nonnuclear combustion (commercial coal or gas-fired power plants), remediation processes air monitoring, and materials handling area ventilation.

COLLABORATION/TECHNOLOGY TRANSFER

An industrial partnership workshop was held November 9, 1993, in Albuquerque, New Mexico to provide all potential industrial partners with information concerning the FTAM. Following the workshop, two proposals were received from potential industrial partners interested in working with DOE on the FTAM. After careful consideration, EG&G Nuclear Instruments, Oak Ridge Tennessee, was selected. EG&G proposed a Cooperative Research and Development Agreement (CRADA) relationship for the commercial development of the FTAM detector technology. Development of the FTAM detector has since progressed so that another option other than a CRADA is being discussed. The possibility of a Developmental License is being discussed between LANL and EG&G as a means of solidifying the relationship and making the technology commercially available. A U.S. Patent (#5,471,062) was granted on November 28, 1995.

Under a nondisclosure agreement, EG&G has been provided full technical information on the detector and is in the process of preparing a proposal package to present to potential customers. Once the package is developed, EG&G will assume lead responsibility for the introduction of the detector to the commercial market. The partnership with EG&G will provide assistance in the following areas:

- Knowledge of manufacturing to simplify the design and reduce time to market
- Definition of testing parameters and analysis of test data
- Access to a radiation calibration facility in Saclay, France for radioactive aerosol testing
- Provision of state-of-the-art systems for baseline comparisons

Accomplishments

- A field test detector was built in FY95.
- Successful field demonstrations of a Plasma Hearth Process (PHP) system occurred in FY95.

TTP Information

Real-Time Monitoring of Alpha Emissions technology development activities are funded under the following technical task plan (TTP):

TTP No. AL1-4-MW-76, "Real-Time Alpha Monitor"

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Bibliography of Key Publications

Gritzo, R.E., M. Fowler, and J. Wouters. "The Development of an Innovative Real-Time Monitor for Airborne Alpha Emissions," 1994 International Incineration Conference, Houston, Texas (May 1994).

Gritzo, R.E., M. Fowler, and J. Wouters. "Real-Time Monitoring of Alpha Emissions," Fiscal Year 1994 Final Report (December 1994).

Gritzo, R.E., J. Farnham, E.P. Chamberlin, and C. Royer. "Real-Time Monitoring of Alpha Emissions," Fiscal Year 1995 Final Report (December 1995).

5.7 Resource Conservation and Recovery Act Characterization Definition

Technology Needs

In order for the PHP to treat low-level waste, compliance with regulatory limits on the emission and disposal of Resource Conservation and Recovery Act (RCRA) constituents is required. To eliminate all hazardous organics by oxidation and reduce the volume of other solid constituents, it is anticipated that the PHP or equivalent process will be used prior to waste disposal. One of the measures to ensure compliance with applicable regulations is to determine the composition of the waste matrix and the concentrations of its RCRA constituents prior to treatment. If this waste is to be treated and disposed of in a most efficient and cost-effective manner, an assay method which can be performed on sealed containers noninvasively and on-line is needed.

Technology Description

This task assists in identifying available technologies that are able to perform, with some modifications or enhancements, nonintrusive, on-line elemental analyses for RCRA constituents on containerized, mixed low-level, and hazardous waste prior to treatment. This project is focused on the PHP for development of performance criteria.

This project is designed to identify the best commercially available noninvasive on-line assay systems for measuring RCRA constituents. It is the objective of this project to:

- Identify commercial vendors with on-line assay systems with the potential for measuring RCRA constituents at the levels required by regulation
- Fund a limited amount of development work by the vendors with the most promising assay systems so that they can partake in an assay of surrogate waste containing known amounts of RCRA constituents that are blind to the participants
- Develop a set of surrogate containerized samples
- Request the participants to perform an elemental assay on the blind nonradioactive surrogate wastes
- Develop a set of criteria prior to the blind assay to evaluate them

Benefits

Assay for RCRA constituents by conventional laboratory methods involves sampling of containerized waste, a costly and time consuming process. Sampling also increases the possibility of causing exposure to personnel, an unsafe working condition, or a release of hazardous material to the environment. This project supports the identification of nonintrusive on-line elemental analysis, thus reducing worker exposure and avoiding a possible release of hazardous material. It is intended that this project will result in one or more useable assay systems and will ultimately advance the current state of the art of noninvasive elemental assay systems.

Collaboration/Technology Transfer

The purpose of this project is to find existing technologies within the private sector, at universities, or at federally operated laboratories that meet the criteria of noninvasive on-line elemental assay of waste prior to treatment. If the technology comes from a federal laboratory, then the laboratory will be encouraged to work with private industry to transfer the technology for widespread utilization.

Accomplishments

- Solicitation was made in the *Commerce Business Daily* for participation in a blind performance test to establish commercial capability in prompt gamma activation analysis.
- Three companies have been identified which are interested in participation in the blind test (i.e., to analyze RCRA metals present in a surrogate waste matrix).
- A complete draft of the Test Plan has been written and distributed to the participants for their comments and suggestions.
- Rust Geotech, at Grand Junction, Colorado, has been identified as the potential developer of the surrogates recipes.

TTP Information

RCRA Characterization Definition technology development activities are funded under the following technical task plan (TTP):

TTP No. ID7-4-MW-77, "RCRA NDE/NDA"

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BIBLIOGRAPHY OF KEY PUBLICATIONS

Gehrke, R.J., R.J. Pawelko, and R.C. Greenwood. "Application of PGNAA to Preincineration Assay of Combustible Waste for Chlorine," *Transactions of the American Nuclear Society* 72 (1995).

Gehrke, R.J., and G.G. Streier. "Plan to Evaluate the Technical Status of Noninvasive Elemental Assay Techniques for Hazardous Waste," draft of February 29, 1996, to be published as a DOE/INEL report.

6.0 CROSSCUTTING PROGRAMS

EM-50 has three crosscutting programs: Efficient Separations and Processing; Characterization, Monitoring, and Sensor Technology; and Robotics Technology Development. Two of these programs, Efficient Separations and Processing and Characterization, Monitoring, and Sensor Technology, are developing technologies for the Mixed Waste Focus Area. Examples of these include:

Efficient Separations and Processing

- Development of water-soluble polymers for the removal of Pu and Am from wastewaters
- Development of a process for the immobilization of fission products within a phosphate-bonded ceramic waste form
- Development and testing of inorganic sorbents for separations
- Development of a process for the removal and recovery of toxic metals from wastewaters
- Production and testing of chemical derivatives of naturally occurring complexing agents for the removal of Pu from wastewaters varying in pH and ionic strength
- Development and testing of novel electrochemical processes for the destruction of nitrates and organics from mixed low-level wastes

Characterization, Monitoring, and Sensor Technology

- The Diagnostic Instrumentation and Analysis Laboratory (DIAL) at Mississippi State University is developing and applying various advanced diagnostic methods for the characterization of plasma properties, melt properties, and downstream emissions from a plasma torch facility.
- Laser-spark spectrometry is being applied to the continuous, real-time, on-line monitoring of metals in an offgas stream in the Metal Emissions Monitor for the DOE Thermal Treatment project.
- The Infrared Analysis of Waste project is developing a Fourier transform infrared (FTIR) spectrophotometer using a heated, long-path measurement cell to be used as a continuous emission monitor for organics in the gaseous emissions of mixed waste thermal treatment systems.

For more information on the Crosscutting Programs, please see the 1996 Technology Summary Books for the Efficient Separations and Processing Crosscutting Program; the Characterization, Monitoring, and Sensor Technology Crosscutting Program; and the Robotics Technology Development Crosscutting Program.

DOE BUSINESS OPPORTUNITIES FOR TECHNOLOGY DEVELOPMENT

WORKING WITH THE DOE OFFICE OF ENVIRONMENTAL MANAGEMENT

The Office of Environmental Management (EM) provides a range of programs and services to assist private sector organizations and individuals interested in working with DOE in developing and applying environmental technologies. Vehicles such as research and development contracts, subcontracts, grants, and cooperative agreements enable EM and the private sector to work collaboratively. In FY95, 39 percent of Office of Science and Technology (OST) funding went to the private sector, universities and other federal agencies. EM's partnership with the private sector is working to expedite transfer of newly developed technology to EM restoration and waste management organizations, industry, and other federal agencies.

Several specific vehicles address institutional barriers to effective cooperation and collaboration between the private sector and DOE. These mechanisms include contracting and collaborative agreements, procurement provisions, licensing of technologies, consulting arrangements, reimbursable work for industry, and special consideration for small businesses.

INFORMATION ON EM

The EM Center for Environmental Management Information provides the most current facts and documents related to the EM program. Through extensive referrals, the Center connects stakeholders to a complex-wide network of DOE Headquarters and Operations Office contacts.

To obtain information from the EM Center for Environmental Management Information, write or phone:

EM Center for Environmental Management Information
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P.O. Box 23769
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THE COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT

The Cooperative Research and Development Agreement (CRADA) is a written agreement between one or more federal laboratories and one or more nonfederal parties through which the government provides personnel, facilities, equipment, and other resources, with or without reimbursement, to support a shared research agenda. The nonfederal parties may also provide funds, personnel, services, facilities, equipment, intellectual property, or other resources to support the research. DOE developed a modular CRADA to be responsive to the needs of participants while protecting the interests of the government and its taxpayers. DOE also has issued the small business CRADA to expedite agreements with small businesses and other partners that meet DOE's requirements. During FY95, EM entered into more than 60 CRADAs.

THE RESEARCH OPPORTUNITY ANNOUNCEMENT

The Research Opportunity Announcement (ROA) is a solicitation for industry and academia to submit proposals for potential contracts in basic and applied research, ranging from concept feasibility through proof-of-concept testing in the field. This mechanism is used when EM is looking for multiple solutions for a given problem. ROAs are issued annually by EM. The EM ROA provides multiple awards and is open all year. ROAs are announced in the *Commerce Business Daily*, and typically published in the *Federal Register*.

For questions on ROAs, contact:

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To learn about EM Technology business opportunities, connect to the METC Homepage:
http://www.metc.doe.gov/business/solicita.html

THE PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT

EM uses the Program Research and Development Announcement (PRDA) to solicit proposals from nonfederal parties for research and development in areas of interest to EM. The PRDA is used for projects that are in broadly defined areas of interest where a detailed work description might be premature. It is a tool to solicit a broad mix of applied research, development, demonstration, testing, and evaluation proposals.

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To learn about EM Technology business opportunities, connect to the METC Homepage:
http://www.metc.doe.gov/business/solicita.html

The Small Business Innovation Research Program

The Small Business Innovation Research (SBIR) Program promotes small business participation in government research and development programs. This legislatively mandated program is designed for implementation in three phases from feasibility studies through support for commercial application. DOE publishes solicitation announcements through the Small Business Innovation Research Office each year to define research and development areas of interest.

For further information about SBIR programs, contact:

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sbir_sttr@mailgw.er.doe.gov

Business Agreements

Cost-Shared Contracts

Nonfederal parties working under DOE contract can agree to share some of the cost of developing a technology for a nonfederal market. This arrangement may involve cash, in-kind contributions, or both.

Grants and Cooperative Agreements

These contractual arrangements provide the recipient with money and/or property to support or stimulate research in areas of interest to DOE. DOE regularly publishes notices concerning grant opportunities in the *Commerce Business Daily*.

Research and Development Contracts

This acquisition instrument between the government and a contractor provides supplies and services to the government. DOE may enter directly into research and development contracts, and DOE laboratories and facilities can subcontract research and development work to the private sector. Announcements on requests for proposals are published in the *Commerce Business Daily* and are available through the EM Homepage on the Internet: *www.em.doe.gov*

Licensing Technologies

DOE contractor-operated laboratories can license DOE/EM-developed technology and software. In situations where DOE retains ownership of a new technology, the Office of General Counsel serves as licensing agent. Licensing activities are conducted according to existing DOE intellectual property provisions and can be exclusive or nonexclusive, for a specific field of use, for a geographic area, United States or foreign usage. Information on licensing technologies may be obtained by contacting the Office of Research and Technology Applications (ORTA) representatives listed later in this section.

Technical Personnel Exchange Arrangements

Personnel exchanges provide opportunities for federal or DOE laboratory scientists to work together with scientists from private industry on a mutual technical issue. Usually lasting one year or less, these arrangements foster the transfer of technical skills and knowledge. These arrangements require substantial cost-sharing by industry, but DOE has an advanced class patent agreement in place for this provision and the rights of any resulting patents become the property of the private industry participant. Contact an ORTA representative for more information.

Consulting Arrangements

Consulting arrangements are formal, written agreements in which a DOE laboratory or facility employee may provide advice or information to a nonfederal party for the purpose of technology transfer, or a nonfederal party may consult with the laboratory or facility. Laboratory/facility employees participating in this exchange of technical expertise must sign a nondisclosure agreement. Contact an ORTA representative for more information.

Reimbursable Work for Industry

This concept enables DOE personnel and laboratories to perform work for nonfederal partners when laboratories or facilities have expertise or equipment not available in the private sector. Reimbursable Work for Industry is usually termed "work for others." An advanced class patent waiver gives ownership of any inventions resulting from the research to the participating private sector company. Contact an ORTA representative for more information.

Office of Research and Technology Applications

Each federal laboratory has an Office of Research and Technology Application. These offices serve as technology transfer agents for the federal laboratories. They coordinate technology transfer activities among laboratories, industry, and universities. ORTA offices license patents and foster communication between researchers and technology customers.

ORTA Representatives:

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PERIODIC TABLE

Of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IB	IIIA	IVA	VA	VIA	VIIA	0
1	1 H Hydrogen																	2 He Helium
2	3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
3	11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorous	16 S Sulfer	17 Cl Chlorine	18 Ar Argon
4	19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
5	37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
6	55 Cs Cesium	56 Ba Barium	57 *La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Wolfram	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
7	87 Fr Francium	88 Ra Radium	89 +Ac Actinium	104 Rf Rutherfordium	105 Ha Hahnium	106 Sg Seaborgium	107 Ns Nielsbohrium	108 Hs Hassium	109 Mt Meitnerium	110 110								

*Lanthanide Series	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
+Actinide Series	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

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ACRONYMS

ABCD	Automated Baseline Change Detection
ACS	American Chemical Society
ANL-W	Argonne National Laboratory-West
ANS	American Nuclear Society
ANSI	American National Standards Institute
ARIES	Autonomous Robotics Inspection Experimental System
ASME	American Society of Mechanical Engineers
BIC	Boreskov Institute of Catalysis
BNL	Brookhaven National Laboratory
CBPCs	Chemically Bonded Phosphate Ceramics
CCO	Catalytic Chemical Oxidation
CDIF	Component Development and Integration Facility
CEM	Continuous Emissions Monitor
CFM	cubic feet per minute
CFR	Code of Federal Regulations
CNF	Central Neutralization Facility
CRADA	Cooperative Research and Development Agreement
CTC	Clemson Technical Center
DC	Direct Current
DCO	Direct Chemical Oxidation
DIAL	Diagnostic Instrumentation and Analysis Laboratory
DOD	Department of Defense
DOE	Department of Energy
EM	Office of Environmental Management
EPA	Environmental Protection Agency
FFCAct	Federal Facilities Compliance Act

FSU	Former Soviet Union
FTAM	Flow-Through Alpha Monitor
FTIR	Fourier Transform Infrared
HEPA	High Efficiency Particulate Air
HQ	Headquarters
ICP-AES	Inductively Coupled Plasma - Atomic Emission Spectrometry
IMSS	Intelligent Mobile Sensing System
INEL	Idaho National Engineering Laboratory
IRF	Incineration Research Facility
ITRC	Interstate Technology and Regulatory Cooperation (Work Group)
LANL	Los Alamos National Laboratory
LDR	Land Disposal Restrictions
LIBS	Laser Induced Breakdown Spectroscopy
LITCO	Lockheed Idaho Technologies Company
LLNL	Lawrence Livermore National Laboratories
LTTD	Low Temperature Thermal Desorption
METC	Morgantown Energy Technology Center
MLLW	Mixed Low-level Waste
MOU	Memorandum of Understanding
MTRU	Mixed Transuranic
MWFA	Mixed Waste Focus Area
NOx	Oxides of Nitrogen
NRC	Nuclear Regulatory Commission
NTP	Nonthermal Plasma
NTW	National Technology Workgroup
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORTA	Office of Research and Technology Application

OST	Office of Science and Technology
OTD	Office of Technology Development
PCB	Polychlorinated Biphenyl
PCT	Product Consistency Test
PHP	Plasma Arc Fixed-hearth Process; Plasma Hearth Process
PIs	Principal Investigators
PRDA	Program Research and Development Announcement
PSIG	Pounds per Square Inch, Gauge
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RFP	Rocky Flats Plant
RFS	Rust Federal Services
RM	Reagent Mix
ROA	Research Opportunity Announcement
SAIC	Science Applications International Corporation
SBIR	Small Business Innovation Research
SCDE	Supercritical Carbon Dioxide Extraction
SRS	Savannah River Site
SSPF	Small-scale Plasma Furnace
STAR	Science and Technology Applications Research
STP	Site Technology Plan
SWAMI	Stored Waste Autonomous Mobile Inspector
TCLP	Toxic Characteristic Leaching Procedure
TOC	Total Organic Carbon
TREAT	Transient Reactor Test Facility
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSCAI	Toxic Substances Control Act Incinerator

TSS	Total Suspended Solids
TTP	Technical Task Plan
TVS	Transportable Vitrification System
VOCs	Volatile Organic Compounds
WETF	West End Treatment Facility
WETO	Western Environmental Technology Office
WHC	Westinghouse Hanford Company
WSRC	Westinghouse Savannah River Company
WTM	Waste Type Manager
WTT	Waste Type Team
XRF	X-ray Fluorescence