DOE/EM--0337

PLUTONIUM FOCUS AREA

Technology Summary
September 1997

The information in this book represents information available and current through February 1997.

FOREWORD

by William Scott, U.S. Department of Energy - Idaho Operations Office, Manager of Plutonium Focus Area (PFA)

The objective of the PFA is to identify and recommend research and technological solutions to issues associated with plutonium stabilization and storage. Research and technology needs are developed using a systems engineering approach in which PFA identifies requirements, solicits research alternatives, recommends acceptable choices, and gauges performance and progress. While the approach has resulted in acceptance of relevant research, a large number of proposals have been rejected. The PFA intends to reverse that trend.

This summary of technology departs from the format of prior PFA summaries by concentrating on the method used to solicit, evaluate, and recommend research. It draws attention to requirements so researchers will concentrate on PFA needs.

I encourage researchers to consult the resources cited in this document. The resources detail requirements for reaching PFA goals. Pet projects and unresponsive proposals will not be recommended for funding. Proposals that respond to the specific needs of PFA stand a good chance of being recommended for funding.

Thank you.

Bill Scott

PLUTONIUM FOCUS AREA

TABLE OF CONTENTS

FIGURES

Tables

WGB.97-0178

1.0 INTRODUCTION

The Assistant Secretary for the Office of Environmental Management (EM) at the U.S. Department of Energy (DOE) chartered the Plutonium Focus Area (PFA) in October 1995. The PFA "...provides for peer and technical reviews of research and development in plutonium stabilization activities..." In addition, the PFA identifies and develops relevant research and technology. The purpose of this document is to focus attention on the requirements used to develop research and technology for stabilization, storage, and preparation for disposition of nuclear materials.

The PFA Technology Summary presents the approach the PFA uses to identify, recommend, and review research. It lists research requirements, research being conducted, and gaps where research is needed. It also summarizes research performed by the PFA in the traditional research summary format. This document encourages researchers and commercial enterprises to do business with PFA by submitting research proposals or "white papers." In addition, it suggests ways to increase the likelihood that PFA will recommend proposed research to the Nuclear Materials Stabilization Task Group (NMSTG) of DOE.

1.1 BACKGROUND

The PFA supports a mission of EM through the Office of Nuclear Material and Facility Stabilization (ONMFS). EM is responsible for managing the cleanup of DOE wastes and nuclear materials from past nuclear weapons production and current operations. The mission of EM includes: (1) bringing DOE sites into compliance with environmental regulations while minimizing risks to the environment, as well as to human health and safety posed by the generation, handling, treatment, storage, transportation, and disposal of DOE waste; (2) stabilizing plutonium (Pu) and other nuclear materials; and (3) deactivating nuclear facilities. The ONMFS, EM-60, in part, supports the Pu stabilization mission. EM-60 leads activities for a variety of programs, including the Defense Nuclear Facilities Safety Board (DNFSB) program entitled "DNFSB Recommendation 94-1" or "Recommendation 94-1" established as a result of concerns raised by this Board.

The Challenge of Recommendation 94-1

The DNFSB, established by Congress (Public Law 100-456) in September 1988, is responsible for the independent, external oversight of all activities affecting public health and safety in the DOE nuclear weapons complex. The DNFSB reviewed operations, practices, and occurrences at DOE defense nuclear facilities and found, with the end of the "cold war," that:

- Fissile material and scrap from retired weapons were left in the production line or stored in an unstable condition.
- Residues and other materials at several sites are in forms that are unsafe.
- Materials at DOE sites produce hydrogen gas, pressurize containers, contain pyrophoric components, and may ignite.

DNFSB concluded in Recommendation 94-1 (May 26, 1994) that corrective actions were needed in the short term (within three to eight years). Two DNFSB sub-recommendations follow:

> *Sub-recommendation* (1): That an integrated program plan be formulated on a high priority basis, to convert within 2-3 years the materials addressed in [seven additional] specific recommendations ..., to forms or conditions suitable for safe interim storage. This plan should recognize that remediation will require a systems engineering approach, involving integration of facilities and capabilities at a number of sites, and will require attention to limiting worker exposure and minimizing generation of additional waste and emission of effluents to the environment. The plan should include a provision that, within a reasonable period of time (such as eight years), all storage of plutonium

metal and oxide should be in conformance with the draft DOE Standard on storage of plutonium now being made final (DOE-STD-3013-96).

Sub-recommendation (2): That a research program be established to fill any gaps in the information base needed for choosing among the alternate processes to be used in safe interim conversion of various types of fissile materials to optimal forms for safe interim storage and the longer term disposition. Development of this research program should be addressed in the program plan called for by (1) above.

DOE not only accepted the recommendation, but issued an implementation plan called "Defense Nuclear Facilities Safety Board Recommendation 94-1 Implementation Plan" or "94-1 Implementation Plan" on February 28, 1995, which addressed the concerns. DOE also established the Nuclear Materials Stabilization Office (NMSO), EM-66, to manage the plan.

Nuclear Materials Stabilization Office

The mission of NMSO, also known as the Nuclear Materials Stabilization Task Group (NMSTG), is to integrate programs for stabilizing excess nuclear materials. NMSTG functions include the following:

- Directing the development needed to support stabilization
- Recommending and directing trade studies of alternatives for treating and storing materials
- Advising DOE of schedule variances and their impacts on commitments and progress
- Developing standards and procedures

EM formed a new focus area group, the PFA, to perform tasks in support of NMSTG functions.

2.0 PLUTONIUM FOCUS AREA

In March 1995, NMSTG chartered a research committee to develop a Research and Development (R&D) Plan addressing short- and long-term needs of the 94–1 Implementation Plan. The research committee completed its function and was disbanded when the plan was issued in September 1995. Implementation and preparation of annual updates of the plan became the responsibility of PFA. The PFA was chartered in October 1995 to provide for peer and technical review of new and continuing research and development activities and to encourage partnerships with DOE to develop stabilization and storage technologies.

The PFA coordinates with the Office of Science and Technology's programs and other focus areas. The PFA organization includes a program manager, a technical manager, a support manager, a Technical Advisory Panel (TAP), and technical staff. PFA was chartered to operate at the Idaho National Engineering and Environmental Laboratory (INEEL) of the Idaho Operations Office with Lockheed Martin Idaho Technologies Company (LMITCO) and Argonne National Laboratory (ANL). The TAP of PFA represents seven field sites of DOE: Hanford Reservation (HAN), INEEL, Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Rocky Flats Environmental Technology Site (RFETS), Oak Ridge National Laboratory (ORNL), and Savannah River Site (SRS). Representation of the seven sites enables integration and balance of stabilization research and makes the assets of the whole DOE complex available to PFA for peer and technical review.

ACCOMPLISHMENTS

1996 Research and Development Plan

PFA published the 1996 R&D Plan Rev. 1 in which PFA identified 100 technology-specific research topics, 19 core technologies, and four new "stewardship" research studies. Of the 100 research topics, 31 technologies were "newly proposed," begun and reported in the 1996 R&D Plan, and 59 were continued from the 1995 R&D Plan. Two required developments were unanswered by any research and eight new research topics were suggested or recommended in the plan. Research was identified in the following categories:

- Storage Standards, Waste Forms, Safeguards, and Security
- Stabilization: Pu, Special Isotopes, High Enriched Uranium
- Storage Technologies
- Engineered Systems
- Core Technology

- Technology Exchange Projects
- Materials Disposition Interfaces and Stewardship

Peer and Technical Reviews

The PFA reviewed 28 white papers in 1996. Seven were recommended for funding by NMSTG, 16 were not recommended for funding, and five are being reviewed. Papers that did not respond to PFA needs and that proposed duplicate research were not recommended for funding. Several white papers submitted in 1997 are being reviewed.

Technology-Specific and Core Technology Research

EM-60/66 funded 21 new technology-specific research projects. Three technology-specific projects, Integrated Monitoring and Surveillance System (IMSS), chemically bonded phosphate ceramics (CBPC), and radioactive scrap metal (RSM) storage containers, are summarized in this document. Of 17 core technologies recommended in PFA's 1996 R&D Plan, EM-60/66 funded 15.

The PFA provided quality assurance program planning for the Plutonium Stabilization and Packaging System (PuSPS) Program. PFA performed requirements analyses, and requirements reviews for PuSPS, RSM, IMSS, and the CBPC research projects.

PFA completed the Ash Residues End-State Trade Study, which identified new technologies for the TAP to consider when treating Pu-bearing Ash.

CONTACTS

William L. Scott
U.S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, ID 83401-1562
Phone: (208) 526-8189
e-mail: scottwl@inel.gov

Dr. Bob Seidel
Argonne National Laboratory
2525 Fremont Avenue
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-2769
e-mail: bob.seidel@anl.gov

Dr. Finis H. Southworth
Idaho National Engineering and Environmental Laboratory
Lockheed Martin Idaho Technologies Company
2525 Fremont Avenue
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-8150
e-mail: fin@inel.gov

2.1 REQUIREMENTS AND GAP ANALYSIS

OBJECTIVES

The DNFSB recommendation 94-1 Implementation Plan commitment to Sub-recommendation (2) requires PFA to monitor and annually measure R&D efforts of a technology-specific program, and a core-technology program. The 94-1 Implementation Plan also requires PFA to use a systems engineering approach. PFA measures R&D effort by performing requirements analyses, trade studies, systems analyses, and technical maturity analyses to formulate requirements against which research can be compared.

APPROACH

PFA measures efforts by comparing 94-1 Implementation Plan requirements with research progress and performance by calculating maturity of technology. Measurements expose gaps that point to research:

- needed but not pursued
- not needed (it happens)
- not proceeding quickly enough
- no longer needed

PFA monitors gaps as they widen or close over time, and recommends adjustments to the 1996 R&D Plan accordingly. PFA uses the following requirements sources:

- Evolving program issues and decisions identified by NMSTG – such as transition of materials from stabilization to stewardship, or direction that acceptable end-states shall be either transuranic (TRU) waste meeting Waste Isolation Pilot Plant (WIPP) waste acceptance criteria or Pu metal or oxide meeting the 50 years storage standard, DOE-STD-3013
- Evolving standards and criteria (such as DOE-STD-3013-96 and criteria for termination of safeguards)
- Trade studies performed by the NMSTG: Salt; Ash; Sand, Slag and Crucible; Metals and Oxides; Combustibles; Scrub Alloy
- List of 151 NMSTG Stabilization Milestones
- 1995 R&D Plan for DNFSB 94-1
- 1996 Baseline Research and Development Technical Requirements Document

- Site Integrated Stabilization Management Plans
- The 94-1 Implementation Plan

The PFA identifies the following types of gaps for both near-term (three to eight years) and long-term (up to 50 years) stabilization technologies:

- Maturity Gaps - R&D that matures too slowly or that has high program risk and can require starting backup technologies, initiating new technologies, or that could result in missing 94-1 Implementation Plan milestones.
- Requirements Gaps - R&D for which no research is assigned. There were six unanswered requirements identified in the 1996 R&D Plan (four related to stewardship and two related to stabilization)

Maturity gaps are measures of program risk that is the product of technical maturity and the probability of failing to meet the required schedule. Requirements gaps also arise from new issues or programmatic decisions (e.g., when a research project fails, with no backup technology).

Requirements gaps for research were identified in 1995 by analysis of Recommendation 94-1 and the 94-1 Implementation Plan. Requirements derived from the analysis were published as the 1996 Baseline Research and Development Technical Requirements Document, which was an input to the R&D Plans published in 1995 and 1996. The R&D Plans are updated annually and are the source for research requirements.

Accomplishments

The PFA developed and published the 1996 R&D Plan. The plan identified two unanswered research topics, eight new technology-specific research topics, four new stewardship research topics, 19 core technology requirements, and improvements in the maturity analysis process.

The 1995 Core Technology Program identified concerns over the diminishing supply of qualified and experienced personnel to perform research and development and stabilization tasks. In 1996 the Core Technology Program initiated 15 of the 19 suggested core technology developments and identified one new research topic.

Conclusions

A complete list of research and technology needed is included in Table 2.1-1. The table lists all the R&D projects needed to meet requirements for research in the 1996 R&D Plan. The purpose of the table is to provide vision into the needs of research and to guide researchers who are submitting relevant white papers to PFA. A brief statement of the focus of each research item is provided to identify the substance of research needs, so that researchers can determine if their research and expertise apply.

Table 2.1-1, which lists required 1996 PFA R&D, includes the location of the research and the phase of its development. The Technical Focus/Issue text in the second column provides a sense of the substance of required research so that researchers can determine if they have something to add to or contrast with on-going or proposed work. The table provides three categories of research requirements:

1. Research for which no development has been identified or suggested (indicated by darkened rows - with bold lettering)

Bold

2. Research that was recommended in the 1996 R&D Plan (from the Introduction, Conclusions, and Recommendations sections indicated by darkened rows - with regular lettering)

Regular

3. Research that was identified and begun in FY 1996 (from the Description and Status sections of the 1996 R&D Plan) or research that was identified and begun in FY 1997 (from the Newly-Proposed R&D Activities/Technologies sections of the 1996 R&D Plan).

Researchers can use the categories to guide their approach to proposing new research and development. Required Core Technologies are listed in Table 2.1-2. Stewardship-related technologies are listed in Table 2.1-3. Researchers are referred to the cited 1996 R&D Plan paragraphs for additional details on required research. Acronyms used in the tables and figures are listed at the end of the book.

Table 2.1-1. Required 1996 PFA R&D

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Storage Standards Technologies	Ensure adequacy of standards for 50-year storage. Provide data to increase confidence in adequacy of the standard. Resolve LOI issues with pure and impure Pu. Understand the phenomenon and develop methods for validating stabilization.	3.1.2	not assessed	
Pu Metals & Oxides	Characterize and understand behavior of impure Pu oxides between 50% and 85% weight Pu.	3.1.2.1	not assessed	LANL
Pu Residues	Ensure safe storage through a surveillance program.	3.1.2.2	not assessed	LANL

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Shelf Life Program	Fill gaps in knowledge of behavior of Pu-bearing materials during storage. Test storage (behavior) of pure and impure oxides as function of water content and temperature. Analyze corrosion effects.	3.1.2.3	not assessed	LANL
Proposed R&D	Evaluate suitability of safe storage of disposal forms that meet waste acceptance criteria (as distinct from transportability). Determine if additional measures are required for safe storage pending transport and disposal.	3.1.4	not assessed	
Waste Forms	Stabilize for storage or convert for disposal. Meet WAC. HLW requires coordination with DOE-MD and DOE-RW. HLWR requirements are not well understood.	3.2.1	not assessed	
High-Level Waste Repository Certification	Determine criteria for spent fuel standard, HLW or deep borehole disposal forms.	3.2.1.1	not assessed	none
TRU Waste	Meet TRU waste WIPP WAC.	3.2.1.2	not assessed	none
LLW	Meet site-dependent LLW WAC.	3.2.1.3	not assessed	none
Safeguards and Security Requirements	Evaluate differing IAEA and DOE safeguards and security standards; design compatible waste forms; and assess site baseline approaches for safeguards.	3.3.2	not assessed	
Mixing TRU with Secondary Materials ...for Reduced Safeguards and Security	Develop mixes of Pu-bearing materials and TRU waste forms that allow reduced safeguards and security.	3.3.3.1	not assessed	new
Proposed R&D	Develop treatment methods to convert materials into TRU waste forms that allow reduced safeguards and security.	3.3.4	not assessed	
Pu Metal Oxide (>50%)	Develop stabilization systems to eliminate organics and plastics.	4.1.1	not assessed	
PuSPS Stabilization	Develop an automated system to stabilize and repackage to DOE-STD-3013-96 and minimize contamination.	4.1.2.1	not assessed	NMSTG
Pu Solutions	Separate and stabilize Pu solutions in near term (1997 to 2000). Select and develop stabilization processes. Track the technical and programmatic progress.	4.2.1, 4.2.5	not assessed	
Extraction Chromatography	Remove interfering elements prior to calcining.	4.2.2.1	2.67	HAN

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Vertical Calciner	Convert solutions to stable, storable solids.	4.2.2.2	3.44	HAN
Precipitation Oxalate/Hydroxide	Complete transfer of nitrate solution stabilization demo-scale-technology to end-use site.	4.2.2.3	3.09	RFETS
Pu Solution Vitrification	Demonstrate vitrification after stabilization of Am/Cm/Np and examine glass forms.	4.2.2.4	5.7	SRS
Ceramification of Pu Solutions	Determine the number of Pu oxide/Pu nitrate infusions required.	4.2.3.1	3.79	RFETS
Pyrochemical Salts	Meet WIPP WAC and safeguards termination criteria for Pu removal. High-risk salt residues contain reactive metals, hydrogen gas, and Am.		not assessed	
Salt Oxidation	Optimize process for MSE salts and salt-strip salts. Transfer the technology to RFETS.	4.3.1.2.1	3.02	RFETS/ LANL
Salt Distillation	Test full-scale NaCl/KCl separation equipment. Investigate and test Ca/Cl_2 process schemes.	4.3.1.2.2	3.44	LANL
Salt Scrub/ Oxidation	Demonstrate automated titration and actinide collection as a metal.	4.3.1.3.1	2.72	LLNL
Salt Filtration	Use a ceramic (zirconia or equivalent) filter medium to condition pyrochemical salt residues. Evaluate on the basis of actinide separation efficiency and process time/conditions.	4.3.1.3.2	3.35	LLNL
Salt Washing	Demonstrate removal of residual Pu from NaCl/KCl salts after actinides have been removed.	4.3.1.3.3	8.23	LLNL
Electro-scrub	Produce alloy button form of Pu for long-term storage. Form must not leave behind unreacted Ca metal in the salt.	4.3.1.3.4	3.93	RFETS/SRS
GMODS	Develop method to convert Pu scrap and residue into a Pu lead- or lead-free borosilicate glass.	4.3.1.3.5	7.49	ORNL
Proposed R&D	Establish clear guidance on reactive materials that are unacceptable to WIPP.		not assessed	
Stabilization of SS&C	Eliminate reactive species and moisture. Define stabilization approaches in trade study. Track program progress.	4.3.2.1	not assessed	
SS&C Stabilization	Dissolve SS&C residues. Pu will be converted to metal. Trade Study recommends the following process: calcine, repackage, and stabilize.	4.3.2.2.1	0.02	SRS

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Calcine for Shipment to SRS	Same as SS&C Stabilization.	4.3.2.2.1	4.7	RFETS
Carbonate Oxidation	Oxidize actinide and reactive metals. Thermal stabilization is being evaluated.	4.3.2.2.2	4.7	RFETS/ LANL
Nitric Acid Soluble Bags	Study acid-soluble bag materials to replace insoluble polyvinyl chloride (PVC) and polyethylene bags.	4.3.2.2.3	0.86	SRS
Cementation	Develop a process to mix ground Pu-bearing material with water. Filter and combine with Portland cement to allow reduced safeguards and security. No further development is needed unless recovery of Pu is necessary.	4.3.2.2.4	4.07	RL
Microwave Vitrification for WIPP	Determine if reactivity of calcium in glass is acceptable under the WIPP WAC. Vitrified product may meet reduced safeguards and security with higher Pu loading than calcined residues.	4.3.2.3.1	4.33	RFETS
Can-in-Canister	Ensure vitrification is compatible with high-level certification process for glass logs. Consider characterization, formulation of glass, surrogate and radioactive tests, and certification. Include ash residues.	4.3.2.3.2	4.98	RFETS/SRS
Vitrification for Can-in-Canister	Demonstrate vitrification of RFETS ash. Demonstrate borosilicate glass formulation with surrogate ash. Verify that off-gas generates no secondary waste; demonstrate use of borosilicate glass and soda-lime silica glass. Use alkali flux for products.	4.3.2.3.3	7.58	RFETS
Electro-chemical Scrubbing	Produce alloy button form of Pu for long-term storage. Form must not leave behind unreacted calcium metal in the salt.	4.3.2.3.4	3.93	RFETS
SS&C Hydrous Cementation	Develop a process to mix ground Pu-bearing material with water. Filter and combine with Portland cement to allow reduced safeguards and security. No further development is needed unless recovery of Pu is necessary.	4.3.2.3.5	4.05	RFETS
Proposed R&D	None identified.	4.3.2.4	not assessed	
Pyrochemical Crucible Residues	Develop backup technologies. Crucible shards are not completely separated from salt.	4.3.3.1	not assessed	
Calcination	**Baseline technology is ineffective.**	**4.3.3.2**	**not assessed**	**RFETS**

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Aqueous Acid Dissolution	Solve process control problems with reactive metals on shards. There are no operable chloride dissolution facilities at RFETS.	4.3.3.3	not assessed	LANL
Molten Salt Washing	Develop process to accommodate shards.	4.3.3.3	not assessed	LANL
Electroscrub	Demonstrate process to accommodate shards. See section 4.3.1.3.4.	4.3.3.3	not assessed	LANL
Combustible Residues	Develop MEO and cryogenic crushing processes. Treating the inventory requires: pretreatment/ size reduction, nitrate removal, destruction of organic matrix, actinide removal, and chlorinated hydrocarbon removal. Technologies are medium to high risk.	4.3.4.1	not assessed	
Polycube Pyrolysis	Destroy styrene matrix and stabilize Pu. Off-gas treatment is being studied.	4.3.4.2.1	4.4	LANL
Pyrolysis (of other combustibles)	Destroy polymer matrix. Remove decomposition products such as gas. Minimize formation of organic liquids.	4.3.4.2.2	6.19	LANL
Catalyzed Chemical Oxidation	Demonstrate full-scale oxidization of hard-to-destroy materials, such as polyethylene and PVC.	4.3.4.2.3	6	RFETS/ LANL/ SRS/ LLNL
Nitric/Phosphoric Digestion	Destroy organics including plastics and resins at moderate temperatures and pressures through a non-incineration process. A pilot system is being built and tested.	4.3.4.2.4	5.79	SRS
Hydrothermal	Conduct treatment studies. Use high-temperature, high-pressure, hydrogen peroxide as an oxidant. A pilot-scale unit has been installed.	4.3.4.2.5	6.05	LANL
Mediated Electrochemical Oxidation (Leach)	Use electrochemically-generated silver (Ag II) as an oxidizing agent to "leach" Pu from combustible oxide and organic matrices. Treatability processes are under study.	4.3.4.2.6	4.53	LLNL/ LANL
Mediated Electrochemical Oxidation (Destruction)	Destroys matrix of combustible materials, such as cheese cloth, paper, and cardboard. Treatability is under study.	4.3.4.2.6	4.16	LANL
Sonication Wash/Dry	Address the following storage concerns: oxidizer/fuel mixtures, hydrogen generation, reactive Pu metal, and corrosion. Sonication wash/dry could meet RCRA extraction criteria.	4.3.4.2.7	6.91	RFETS/ LANL

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Ion Exchange Resin Denitration	Remove exchangeable nitrate and Pu from 19 drums of RFETS ion exchange (IX) resin through use of salicylate. Development of this approach has been completed. Cementing of solutions is underway.	4.3.4.2.8	3.44	RFETS/ LANL
Cryogenic Size Reduction	Install and demonstrate cryogenic-based embrittlement and size reduction methods as pretreatment before other stabilization. The process has been tested. Optimization is required.	4.3.4.2.9	5.93	RFETS/ LANL
Steam Reformation	Determine Pu material balance requirements. Demonstrate reforming.	4.3.4.3	6.21	SEG
Proposed R&D	Require gas generation rate data on dry combustibles to quantify the cost benefit of matrix destruction technologies.	4.3.4.5	not assessed	RFETS
Ash Residues	Resolve issues of WIPP limits, aqueous Pu separation operations, and shipment of ash.	4.3.5.5	not assessed	
Pre-treatment/ Thermal Stabilization	Investigate and successfully demonstrate a wash process to upgrade ash residues from 24% to approximately 70% Pu for storage.	4.3.5.2.1	0.7	LLNL
Silver Persulfate Dissolution	Develop a glove box-sized process to convert dissolved Pu to Pu sulfate, to be converted to Pu oxide for storage. This development is dependent upon field office decisions.	4.3.5.2.2	4.91	HAN
Vitrify in MPPF (for Can-in-Canister Disposition)	Demonstrate vitrification of RFETS ash. Demonstrate borosilicate glass formulation with surrogate ash. Verify that off-gas generates no secondary waste. Demonstrate use of borosilicate glass and soda-lime silica glass. Use alkali flux for products.	4.3.5.2.3	5.6	SRS
Vitrify at RFETS	Same technical focus/issue as "Vitrify in MPPF"	4.3.5.2.3	7.58	RFETS
Ceramify for WIPP	Develop and implement a process in which a Pu nitrate solution is infused into a substrate, heated to 500+C in a furnace, denitrated, converted to hydroxide, and incorporated into a ceramic suitable for disposal at WIPP.	4.3.5.2.4	7.49	RFETS

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Microwave Vitrification for WIPP	Develop and demonstrate vitrification adequate for treating ash residue to a form suitable for disposal at WIPP. Develop a model for selecting frit. Fabricate glass from real and simulated ash compositions.	4.3.5.3.1	4.44	RFETS
MEO in NSR	Demonstrate cold and hot versions of process. The MEO prototype using a Pu surrogate is done. MEO integration into NSR facility is required.	4.3.5.3.2	4	SRS
Can-in-Canister	Ensure vitrification is compatible with high-level certification process for glass logs. Consider characterization, formulation of glass, surrogate and radioactive tests, and certification. Include ash residues.	4.3.5.3.3	2.81	SRS
Scrub Alloy	Recommend per Trade Study that scrub alloy be repackaged, shipped to SRS, processed in F-Canyon and FB-Line, and the resulting metal stored in accordance with DOE-STD-3013 for long-term storage at SRS or RFETS. The technology base is adequate.	4.3.6.1	not assessed	
Scrub Alloy Processing	Use already developed dissolution/ purification flow sheet.	4.3.6.2.1	1.07	SRS
Impurity Chlorination	Demonstrate non-aqueous separation of Pu in anode heels from salt and other materials. Feasibility has been demonstrated on impure Pu metal alloys. The needed equipment exists. An operational envelope is to be established.	4.3.6.3.1	1.81	LLNL
Proposed R&D	Determine if calcium/gallium scrub alloy is compatible with F-Canyon operations.	4.3.6.5	not assessed	
Miscellaneous Pu Residues	Formulate a Small Sites/Small Holdings committee remediation plan where no path exists. Items in storage include insulation, ceramics, contaminated scrap metals, fire brick, and crucibles. Solids may have been packaged in plastic.	4.3.7.1	not assessed	

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
No technology under development.		4.3.7.2	not assessed	none
Multi-Purpose Processes	See sections 4.3.8.2.1, 4.3.8.3.1,2, and 3.	4.3.7.3	not assessed	SRS
Proposed R&D	Develop new stabilization approaches for materials found to have no path forward.	4.3.7.4	not assessed	
Multi-Purpose Processes	Determine inventories with no path forward. Residues with no path forward may require multi-purpose processes. Investigate the multi-purpose process as backup option in the event the mainline options fail.	4.3.8.1, 4.3.8.4, 4.3.8.5	not assessed	
F-Canyon Dissolution	Study general purpose process to dissolve Pu scrap and residue, with purification and conversion to Pu metal.	4.3.8.2.1	not assessed	SRS
GMODS	Develop method to convert Pu scrap and residue into a Pu lead- or lead-free borosilicate glass.	4.3.8.3.1	not assessed	ORNL
Enhancing Cemented Waste Forms	Evaluate supercritical carbon dioxide treatment to transform Pu residue into geologically stable calcium carbonate cement cylinders.	4.3.8.3.2	not assessed	LANL
Plasma Hearth Process and Plasma Arc Process	Melt components using a high-temperature plasma arc. This process is being developed to convert TRU waste on a large scale. The process may not handle salts and feeds where volatile Pu compounds are formed.	4.3.8.3.3	not assessed	ANL
Proposed R&D	Conduct an inventory assessment. Determine if multi-purpose processes are needed for miscellaneous residue items with no path forward.	4.3.8.5	not assessed	
Special Isotopes	Pursue site baseline stabilization technologies. The technology is low risk. Adequate time is available to meet R&D need dates. The technology base is adequate.	5.5	not assessed	
Am/Cm Product Test	Develop vitrification pretreatment operations to support lanthanide and actinide separation. Specific volumes and settling rates of the precipitate slurry were measured during oxalate precipitation of the Am/Cm solution.	5.2.1	0.51	SRS

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Am/Cm Vitrification	Address pre-treatment, vitrification, temporary storage of glass, transportation, and recovery of Am/Cm. Study of tank contents, pretreatment, glass formulation and physical properties have been completed. The mock-up/ demonstration is scheduled for 6/97.	5.2.1	4.51	SRS
Neptunium Flowsheet	Develop a process to convert neptunium into an oxide or glass. Gamma dose/solubility precludes transfer to HLW for processing into saltstone. Radiation levels in saltstone fail LLW criteria. Facilities and techniques have been assessed. Processing into an oxide or glass is an option.	5.2.2	5.95	SRS
(^{238}Pu) ^{242}Pu Stabilization	Convert ^{242}Pu to oxide in FY97. Support is required. Flow-sheet development has been completed. ^{238}Pu was stabilized in FY 96.	5.2.3	0	SRS
Uranium in MSRE	Correct problems at the MSRE site. The technology base is adequate.	6.4	not assessed	
Trapping of Uranium Hexafluoride	Develop and install a system for trapping uranium hexafluoride.	6.2.1	0.42	ORNL
Direct Fluorination of MSRE Salt	Remove uranium by sparging molten salt with fluorine gas. Uranium hexafluoride was trapped and converted into triuranium octoxide for long-term storage. R&D has been completed.	6.2.2	3.23	ORNL
Electro-chemical Treatment of MSRE Salt	Examine electrolytic ion displacement using a lithium anode to convert salt to waste form while removing uranium.	6.2.3	7.49	ANL
GMODS	See section 4.3.8.3.1 for focus of GMODS.	6.3.1	7.49	ORNL
Packaging with Getter	Examine packaging of salt for long-term storage. A catalytic getter within the package is required to prevent buildup of $^{233}UF_6$ or F2.	6.3.2	4.28	ORNL
Charcoal Treatment	Investigate treating charcoal that contains absorbed $^{233}UF6$, F2. The objective is to reduce the potential for exothermic chemical reactions. Charcoal is to be removed and oxidized for storage of ^{233}U as oxide.	6.3.3	3.02	ORNL

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Packaging Technologies	Study methods and equipment to package materials in containers meeting DOE-STD-3013 long-term storage criteria. Develop technologies and procedures for surveillance on items in storage. The technologies are low-risk.	7.1.1, 7.1.5	not assessed	
PuSPS Packaging	Procure an end-to-end automated system that will stabilize and package Pu oxides and metal. A design review was held. An LOI test was performed.	7.1.2.1	3.02	NMSTG
Electrolytic Decon	Package, weld, and leak-check inner "3013" containers in glove box separated into contaminated and uncontaminated sides. Electro-polish cans were decontaminated and verified to meet specifications as well as leak-checked.	7.1.2.2	3.09	LANL
FB-Line and LLNL Bagless Transfer	Address the unique facility constraints in FB-Line. The same approach was taken as in the PuSPS process. Evaluate the arc gap, weld current, cut height, and rotation speed. Perform destructive met allurgical evaluation and burst testing.	7.1.2.3	2.77	SRS/LLNL
Dustless Oxide Transfer	Transfer oxide powders without generating dust. The prototype was tested with surrogate materials and with Pu.	7.1.2.4	2.09	LLNL
Recycled Metal Study	Study life-cycle cost, accountancy, availability, transportability, material behavior, and ability to meet national standards.	7.1.2.5	not assessed	INEEL
Pipe Component	Determine if the design meets storage container requirements. Modify the design to a DOT-Type B container. Plan an IAEA dynamic crush and DOT 30-minute fire-test. Performance test of design has been completed.	7.1.2.6	3.93	RFETS
^{239}Pu Standard Container	Procure a container test lot. Competitive procurement will follow.	7.1.2.7	2.67	NMSTG
Surveillance	Develop non-intrusive techniques in an integrated system. Assemble a representative inventory. Detect changes in pressure and gas composition. Observe changes in double can. The technology is adequate and low-risk.	7.2.2, 7.2.5	not assessed	

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Digital Radiography	Gain information on metal, oxide, residues, commercial equipment. Determine corrosion products, assess corrosion, and detect pressurization. A radiography system has been installed. Study image resolution for detecting deformation and radiography for measuring bulging.	7.2.2.1	1.14	LANL
Tomography	Investigate x-ray tomography for non-invasive determination of contents and condition. Investigate identifying Pu corrosion products. Investigate measurement techniques complementary to computerized tomography. Prototype equipment has been installed and tested.	7.2.2.2	3.88	LANL
Laser Sampling	Develop a system to sample gas in a sealed container using laser penetration to release a gas sample and reseal the container. The research project is complete, and the system is ready for delivery.	7.2.2.3	4.93	LANL
Acoustic Resonance Spectroscopy	Develop a non-intrusive pressure and composition change detection system. Study behaviors of gas modes, temperature, pressure, and mixture while using surrogate materials.	7.2.2.4	4.23	LANL
Pressure-Sensitive Devices	Develop aneroid bellows and micro-electronic hydrogen sensors to detect gas generation and determine if restabilization and repackaging are required. The sensor system is to be tested. The sensor should avoid breaching the container.	7.2.2.5	3.95	LANL
Risk-Based Prioritization of Residues	Develop a methodology to evaluate the probability of failure containment barriers and calculate probabilities on risk event trees. Workshops were conducted and components of the methodology were developed.	7.2.2.6		LANL
Non-Destructive Assay, Surveillance of Pu	Evaluate gamma ray analysis of heterogeneous materials to support both calorimetric assay and neutron measurements. Evaluate both neutron and calorimetric assay and apply finite element analysis to predict calorimeter performance.	7.2.2.7	not assessed	

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	Technical Maturity	Location
Integrated Surveillance	Develop an integrated data acquisition, storage, and retrieval system. Characterize stabilized Pu-bearing packages, perform surveillance and monitoring, and track containers throughout the DOE complex.	7.2.3.1	not assessed	INEEL
Neutron Interrogation Measurement	Evaluate techniques of analysis of moderated neutrons and prompt-gamma neutron activation analysis to replace the conventional LOI method.	7.2.3.2	not assessed	new
Thermal Modeling of Temperature Distribution	Develop a model to predict temperatures of Pu metal and oxide under various storage configurations. Make physical measurements to perform shelf-life storage studies and design storage vaults.	7.2.3.3	not assessed	new
Proposed R&D	Develop non-intrusive surveillance to monitor packages. Develop digital radiography/ tomography, acoustic sampling, and pressure-sensitive devices for nonintrusive surveillance. Detect changes in pressure and composition, and observe changes in double cans.	7.2.5	not assessed	
Engineered Systems	Integrate automation requirements into baseline R&D TRD. Conduct a trade study to examine/recommend development of baseline hardware, software, and human factors requirements.	8.4.1, 8.5	not assessed	
Modular Concepts	Develop-optimize an integrated, skid-mounted, modular processing system. Provide the flexibility to process different materials with the least effect on the system.	8.2.1	not assessed	LANL
PuSPS Integration	Procure an automated system from BNFL to stabilize/package Pu metals/oxides in DOE-STD-3013 packages. Prototype the system at various sites.	8.2.2	not assessed	NMSTG
Proposed R&D	Establish automation requirements and conduct a trade study or needs assessment to examine and develop baseline hardware, software, and human factors. Evaluate the necessity/validity of using automated technology.	8.5	not assessed	

Table 2.1-2. - Core Technology Research and Development Requirements

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	LANL Core Technology Project Title
Core Technology	Provide a better understanding of actinide science. Develop an understanding of processes that affect stabilization. Predict the long-term behavior of materials in storage. Develop the capability to address unforeseen problems with managing these materials.	9.1	
Actinide Solution Chemistry	Focus on Pu solution chemistry. Complete experiments aimed at understanding chemistry of Pu (IV) in nitric acid, at the molecular level, at high acid concentrations. Explore the effects of halide and alkali metal ions on Pu complexation.	9.2.1.1	Actinide Solutions
Chemical and Physical Interactions of Actinides with Surfaces	Characterize and image the surface interaction between actinide species and substrates. Use silicates to represent dominant phases in ash. Use diffuse reflectance, luminescence, photoacoustic, Raman, and x-ray spectroscopies.	9.2.1.2	Actinide/Surface Interactions
Changes in Chemical State of Pu	Study time-dependent chemical behavior of Pu-containing materials. Use x-ray absorption spectroscopy, x-ray diffraction and photoelectron spectroscopy. Collaborate with research on aging effects.	9.2.1.3	Pu Chemical State Changes
Actinide-Organic Interactions	Study pyrolysis, MEO, and hydrothermal catalyzed chemical oxidation to destroy the organic matrix. Focus on interactions in solid organic matrices and on complexation of organic species in aqueous solution. Synthesize organo-metallic compounds of actinides.	9.2.1.4	Actinide-Organic Interactions
Polymer Filtration	Optimize polymer filtration. Study solubility, filterability, binding strength, and capacity. Develop direct probing techniques to characterize metal-bonding. Obtain structure-function relationship. Develop synthetic procedures for optimized polymers.	9.2.2.1	Polymer Filtration
Polymer Foams	Develop microcellular polymeric foams to overcome efficiency problems. Demonstrate use of polymer foams for actinide separation. Study phosphonic, phosphonate acid groups and poly-vinylpyridine units. Investigate metal ion uptake and graft polymerization.	9.2.2.2	Polymer Foams

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	LANL Core Technology Project Title
High Temperature Thermodynamics and Kinetics	Maintain competency in experimental actinide chemical thermodynamics and kinetics. Focus on the vaporization behavior of Pu oxychloride. Study Am oxychloride and alkali halide/ actinide oxyhalide salt mixtures.	9.2.3.1	Thermo-dynamics
Corrosion	Examine crystallographic orientation effects on the electrochemical behavior of materials. Discern the effect of surface structure on pitting. Study the stochastic nature of corrosion. Improve corrosion resistance through surface processing or texturing.	9.2.3.2	Corrosion
Diffusion	Measure diffusion coefficients of Pu in stainless steel, predict behavior, and integrate information from literature with direct measurements on aged material and models.	9.2.3.3	PuDiffusion Science
Vitrification	Develop and demonstrate a glove box-scale vitrification process. Study vitrification as an alternative to cementing certain Pu-contaminated waste materials and procure, cold test, and install equipment.	9.2.3.4	
Mineral Waste Forms	Enhance alternate waste forms for stabilizing Pu. Determine solubilities of Pu in binary actinide-silicate/ ternary actinide-zirconium-silicates. Study temperature, pressure, and material effects on reaction rate, yield, and microstructure.	9.2.3.5	Mineral Waste Forms
Pu (III), (IV), and (VI) Phosphates	Develop an understanding of Pu phosphate chemistry in solution and solid states. Use synthetic efforts, structural, spectroscopic, and analytical characterization and focus on synthesis and structure of Pu (III), Pu (IV), and Pu (VI) compounds.	9.3.1	Pu IV and Pu VI Phosphates
Nonaqueous Actinide Electrochemistry	Study electrochemical transfer reactions of actinides and actinide complexes. Stabilize oxidation states that are not accessible in aqueous acidic media. Measure thermodynamic reduction/ oxidation potentials and heterogeneous electron transfer kinetics.	9.3.2	Molten Salt/Non-Aqueous Electro-chemistry

R&D Category/ Technology	Technical Focus/Issue	R&D Plan Paragraph	LANL Core Technology Project Title
Actinide Self-Fluorescence	Develop analytical methods and instrumentation for nondestructive assay and evaluation. Investigate self-fluorescence signatures. Develop computational techniques to model gamma, beta, and alpha transport; and interpret self-fluorescence signatures.	9.3.3	
Extractive Scintillators for Alpha Counting	Develop fast, sensitive procedures for quantifying alpha emitters in aqueous media. Use a Photon Electron Rejecting Alpha Liquid Scintillation spectrophotometer and extractive scintillators. Test extractive scintillators and solid exchangers.	9.3.4	Alpha Detection
Environmentally Assisted Cracking of 304 Stainless Steel	Determine cracking susceptibility as a function of nitric acid, halide concentration, and sensitization level. Examine mechanisms that control cracking.	9.3.5	
Plutonium Chemistry in Aqueous Sulfate/ Phosphate Media	Develop a process for recovering Pu from solutions. Explore complex phosphates with low solubility; decontaminate phosphate solutions for disposal as LLW. Study the effect of partially-oxidized organic acids.	9.3.6	Pu Phosphate/ Sulfate Solutions
New R&D	None specified.	none	Hydrous Polymers
Proposed R&D	Identify program elements that contribute to underlying science and maintain core competencies. Define expertise to be maintained. Develop assessment of R&D. Define gaps within the core technology program.		See note below

Note: Identified in Table 2, page 72 of "94-1 Research and Development Project Lead Laboratory Support," LA-13261-PR Progress Report, UC-940, issued December 1966 (see web page http://lib-www.lanl.gov/la-pubs/00326302.pdf).

Table 2.1-3. Stewardship Research and Development Requirements

R&D Category; Technology	Technical Focus/Issue	R&D Plan Paragraph
Materials Disposition Interface and Stewardship Technology	Identify new R&D requirements, or "gaps" in the current R&D efforts.	1.3
Adequacy of disposal configurations	Determine if additional measures are required for the safe interim storage of materials awaiting transportation and disposal.	1.3, Table 1-1
Suitability of HLW Forms	Assess new waste forms to ensure that their repository performance characteristics are bounded by the reference waste forms. Coordinate treatment of can-in-can materials with DOE-MD and DOE-RW programs.	1.3, Table 1-1
Safeguards and Security Stabilization	Assess which baseline stabilization approaches will not meet safeguards and security requirements. Convert materials into TRUW forms that allow reduced safeguards and security.	1.3, Table 1-1
Automation Requirements	Conduct a trade study to determine the necessity of automation for monitoring, packaging, and handling of storage containers.	1.3, Table 1-1

BENEFITS

The requirements and maturity analysis approach provides a justifiable research program that pursues needed research and avoids unneeded research. The 1996 R&D Plan identifies specific research that the research community can reference to focus/contribute to meeting stabilization milestones. Maturity requirements analysis methods enable PFA to rank, select, or reject research ideas.

CONTACTS

Dr. C. Robert Kenley
Advanced Engineering Development Laboratory
Lockheed Martin Idaho Technologies Company
Forrestal Building
Washington, D.C. 20585
Phone: (202) 586-6183
e-mail: kenlcr@inelmail.inel.gov

Don Schilling
Advanced Engineering Development Laboratory
Lockheed Martin Idaho Technologies Company
2525 Fremont Avenue
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-0248
e-mail: dons@inel.gov

2.2 Integrated Monitoring and Surveillance System Demonstration Project

Technology Needs

There is a need to develop and demonstrate a prototype monitoring and surveillance system. The need was identified as a "gap" in the original 1995 R&D Plan. The recommendation stated: "Develop a surveillance system for monitoring Am/Cm and Pu238 in storage." Sites within the DOE complex have plans to store Pu materials in packages (called "3013" containers) meeting requirements of DOE-STD-3013-96. Storage system requirements include Pu accountability, safeguards and security, and maintaining health and safety. Container monitoring and surveillance systems are being studied as an approach to meet storage system requirements. A prototype surveillance system is needed for configuring performance tests on which sites can base alternative designs for meeting regulatory requirements.

There is also a need to define a minimum set of requirements for storage and surveillance of Pu materials. Storage systems that meet DOE-STD-3013-96 must also adhere to other applicable directives, rules, orders, guidelines, and regulations. For example, DOE-STD-3013-96 states that "*Storage facility design, safeguards and security interfaces, and transportation requirements are addressed in detail by other* DOE *directives (e.g., rules, orders) and other agencies' regulations. Such requirements are not repeated in this standard. However, users of this standard are advised to consult and assure adherence with other applicable directives while implementing these criteria.*"

There is a risk of significant financial and schedule impact if storage and surveillance system designs are either delayed, too robust, unachievable, or incomplete. The number of storage containers to be monitored is large, possibly exceeding 10,000. A design for monitoring and surveillance systems is already underway to coordinate with storage needs in the early part of the 21st century.

Technology Description

Argonne National Laboratory - West (ANL-W) and LMITCO are developing, designing, and testing a prototype integrated system, according to requirements in the Integrated Surveillance System Phase I Report issued by PFA for the surveillance and monitoring of stabilized Pu and Pu-bearing materials in storage. The product will be a baseline Integrated Monitoring and Surveillance System (IMSS). The baseline system will be installed in an operational nuclear material vault at ANL-W and will be used to evaluate and contrast vault and Pu package monitoring and surveillance sensors, using different storage configurations under both normal and transient conditions. The prototype

IMSS will be used to evaluate proposed guidelines and procedures and to demonstrate system responses for training purposes.

The performance of a given set of sensors is dependent on the storage configuration used. To account for this dependence, the prototype IMSS will incorporate several "3013" package storage configurations, including the "bird cage," the "10-gallon drum," the "hanging basket," and the "pedestal storage" options. DOE-STD-3013-96 recognizes the importance of heightened monitoring immediately following packaging, particularly in the case of packaged oxides. Once the package has survived for a certain period of time, the level of monitoring may be reduced to save resources. The IMSS prototype will account for this by including two separate storage and sensor test areas: a storage area, where devices designed for heightened package monitoring will be tested, and a long-term storage area, where the birdcage and 10-gallon drum configurations will be located. The prototype IMSS will provide an integrated monitoring and surveillance system for evaluation and testing of material, and vault monitoring devices and procedures. A schematic, representing two key aspects of the IMSS prototype, is shown in Figure 2.2-1.

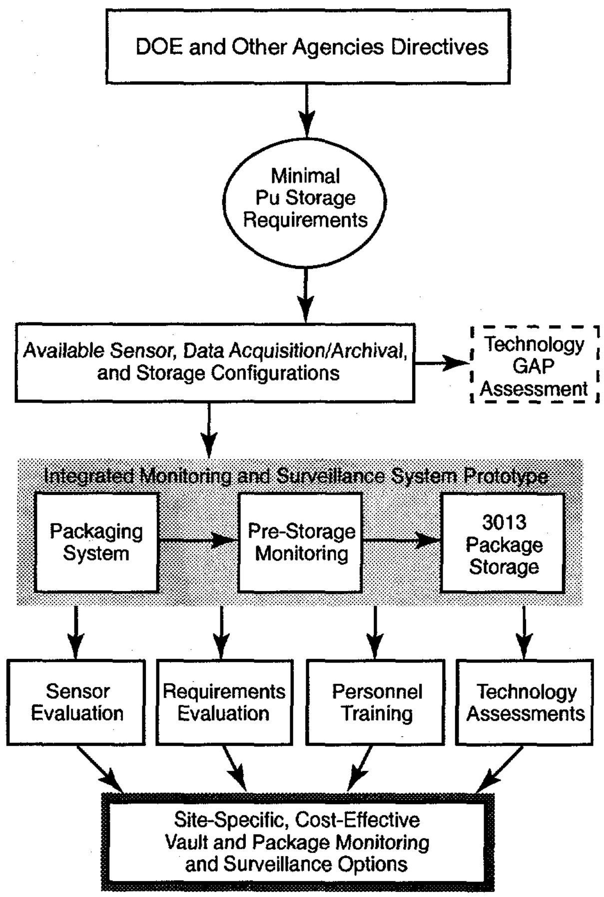

Figure 2.2-1. Integrated Monitoring Surveillance System Summary Schematic

The proposed system will merge tasks and technologies necessary to monitor material stability and package integrity, material control and accountability, as well as environmental, safety, and health controls. It will perform data acquisition and analysis. The prototype will be designed in a standardized form such that equivalent systems may be used throughout the DOE complex. The prototype will also monitor multiple sites simultaneously from a central location. Flexibility will be designed into the prototype such that, as experience is accumulated and as new technologies emerge, potential system modifications can be tested and characterized before being installed complex-wide.

In keeping with the standardized nature of the proposed IMSS prototype, existing technologies, (e.g., sensors and detectors from government and industry sources) will be utilized. Sensors will be integrated into an existing reporting system and networked to a central information hub capable of monitoring numerous facilities simultaneously. System design and operations will incorporate consideration for material stabilization and package constraints, thus minimizing necessary assay and verification measurements, increasing system fidelity, and optimizing system operations and performance.

ACCOMPLISHMENTS

Source documentation has been assessed and an initial set of requirements established. The requirements set was reviewed by experts representing affected DOE sites. Sensor technologies have been identified and screened based on the preliminary requirements. Demonstration test facilities and materials have been identified and are being readied for installation with the IMSS prototype and a data acquisition/archival system has been designed and is being procured. IMSS prototype fabrication and assembly has begun.

BENEFITS

The use of a minimum requirements set will aid individual sites in selection of package and vault monitoring sensors that best suit their needs while assuring adherence to all applicable directives.

The prototype IMSS will provide a means of comparing sensor/storage configuration performance against a baseline integrated system and demonstration of system capabilities. It will permit testing of new hardware and software designs before purchase and installation in vaults within the DOE complex. It will provide a system for evaluation and testing of material and vault monitoring devices and procedures The prototype will be valuable in determining where technology gaps may exist, thus allowing for the most efficient allocation of scarce resources.

The IMSS prototype will conserve resources by allowing individual sites the opportunity to choose the most efficient and effective sensor systems. In addition, the prototype will facilitate standardized practices and equipment systems that promote system integration and interfacing for cost-effective stabilization, offer disposition preparation options, and provide a means of future cost savings for sites within the DOE complex.

CONTACTS

Steven E. Aumeier, Ph.D.
Argonne National Laboratory West
P.O. Box 2528
Idaho Falls, ID 83403-2528
Phone: (208) 533-7479
e-mail: aumeier@anl.gov

B. Gail Walters
Argonne National Laboratory West
P.O. Box 2528
Idaho Falls, ID 83403-2528
Phone: (208) 533-7044
e-mail: gail.walters@anl.gov

2.3 RADIOACTIVE SCRAP METAL FABRICATION OF "3013" CONTAINERS

TECHNOLOGY NEED

Containers meeting DOE-STD-3013-96 are required by the DOE complex to store stabilized Pu. DOE seeks to reduce costs for storing RSM and offset costs of disposition using containers made from virgin metal.

TECHNOLOGY DESCRIPTION

Storage containers using RSM are to be designed, developed, fabricated, and tested to meet DOE-STD-3013-96 standards. Procurement is to be directed by DOE-ID. Ten cans are to be used in tests and demonstrations and 100 cans are to be made available to the PuSPS and IMSS Research and Development projects. A design report will be written describing each phase of the project. A requirements document will be produced to guide the procurement process.

Containers will be constructed of recycled, contaminated steel and nickel from the Oak Ridge K-25 facility. Chromium and other needed elements will be purchased commercially. Quality assurance (QA) based on the ANL-W QA plan for the PuSPS project would be conducted jointly by LMITCO and ANL-W. LMITCO would be responsible for environmental compliance, design evaluation, and evaluation and qualification of RSM.

ACCOMPLISHMENTS

A technical requirements document was developed identifying risks, standards, functions and interfaces, and issues related to "3013" containers. QA, operational concepts, and project termination criteria were identified. The project was put on hold in January 1997 due to lack of funding.

BENEFITS

This project would provide a second source for "3013" containers and permanently remove radioactive scrap metal from expensive storage.

Contact

Don Schilling
Advanced Engineering Development Laboratory
Lockheed Martin Idaho Technologies Company
2525 Fremont Avenue
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-0248
e-mail: dons@inel.gov

2.4 Trade Study on "End-State of Ash Residues"

Technology Need

NMSTG requested a trade study to identify the most desirable pathways to acceptable end-states for Pu-bearing ash residues. NMSTG incorporated the findings of the trade study and studies of other residues, stakeholder concerns, and policy issues into its decision sequence. The trade study was one of six major trade studies on Pu residues sponsored by NMSTG.

Technology Description

The study was directed by DOE-ID and conducted by a team with representatives from INEEL and sites having Pu-bearing ash holdings. Preferred methods of stabilization were determined for stabilizing 21 metric tons of ash residues located at RFETS, LANL, HAN, SRS, and others. The team identified the most desirable pathways to acceptable end-states, based on efficiency, cost, waste generation, facility capabilities, worker safety, and public safety as ranking criteria.

The study considered requirements of the 94-1 Implementation Plan milestones schedule, the initial conditions of ash, issues of end-state acceptance criteria, and safeguards termination criteria. Definition of requirements and measures of performance for each alternative were predicated on a process description; facility requirements; equipment requirements; throughput capability; storage location and capacity; surveillance and monitoring activities; transport requirements; and requirements of the National Environmental Policy Act.

Accomplishments

The study team identified and investigated 41 processing options distributed among four alternative end-state paths. The four paths were: "No Action," "Separate and Store," "Treat, Stabilize, and Store," and "Repackage."

Twenty-three technologies were assessed for the RFETS ash. The life-cycle costs of RFETS technology options are presented by alternative end-states in Figure 2.4-1. The options considered for application at other sites are listed in Table 2.4-1.

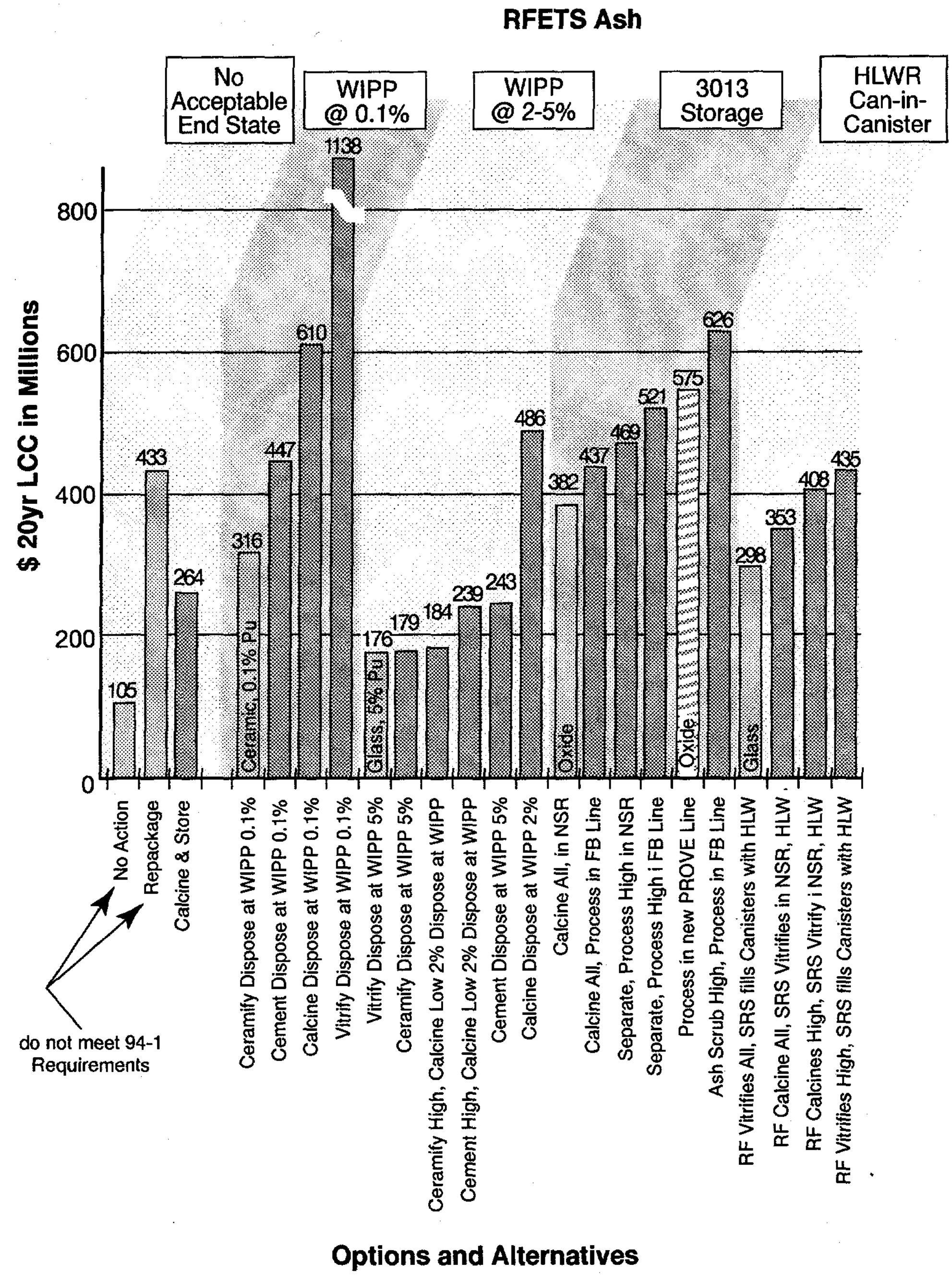

Figure 2.4-1. RFETS Ash End-State Alternatives and Processing Options.

Table 2.4-1. Technology options listed below were addressed for four other installations with ash residue.

Site	Technology Option
HAN	Silver Persulfate Aqueous Separation
	Vitrify, SRS fills Canisters with HLW
	Process to Oxide in NSR
	Cement, Dispose at WIPP
	No Action
LLNL	Wash, Calcine, Store
	Calcine, Process to Oxide in NSR
	Calcine & Store
	Vitrify, SRS fills Canisters with HLW
LANL	Cold Press & Sinter,
	SRS fills Canisters with HLW
	Aqueous Chloride Separation
	Aqueous Nitrate Separation
	Calcine, Dilute, Dispose at WIPP in Pipe
	Cold Press & Sinter, Dispose at WIPP
	No Action
	Cement, Dispose at WIPP
	Calcine, Dilute, Dispose at WIPP in Drums
SRS	Do Experiments
	Recommended Backup

BENEFITS

The study contributed to a programmatic decision by NMSTG to establish silver persulfate dissolution research at HR and establish a new baseline for in-furnace (microwave) vitrification of ash at the RFETS.

CONTACTS

Dr. Finis H. Southworth
Idaho National Engineering and Environmental Laboratory
Lockheed Martin Idaho Technologies Company
2525 Fremont Avenue
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-8150
e-mail: fin@inel.gov

Don Schilling
Advanced Engineering Development Laboratory
Lockheed Martin Idaho Technologies Company
2525 Fremont Avenue
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-0248
e-mail: dons@inel.gov

2.5 STABILIZATION OF PU-CONTAINING RESIDUES IN CHEMICALLY BONDED PHOSPHATE CERAMICS

TECHNOLOGY NEED

Technology demonstrations using CBPC have stabilized heavy-metal-containing ash and produced ceramic monoliths with very low rates of metal leachability. More than 20 metric tons of ashen products in the DOE complex, most of it at RFETS, await stabilization and transport to WIPP. PFA recognized that CBPC is a technology for economically stabilizing ash and other plutonium-bearing residues and potentially rendering it disposable at WIPP.

For application of the CBPC technology to plutonium bearing ash, the primary criteria of acceptability are:

- radiolytic gas generation rates being within acceptable limits for transport in a Transuranic Waste Packaging and Transport Container II
- stabilization of the fissile-material-containing residues into a form for which the fissile material is "practically irrecoverable"
- stability at high levels of carbon content, which is characteristic of RFETS ash

TECHNOLOGY DESCRIPTION

Among the group of materials called "ceramic" is a class of chemically-bonded ceramics that are manufactured at room temperatures. The materials are formed by ionic- and covalent-bonding reduction reactions at low temperatures. Materials are formed that are comparable in strength to more conventional ceramics formed by high temperature sintering or fusion. The chemically-bonded ceramics are much stronger than typical room-temperature hydraulic cements, which are bound by comparatively weaker Van der Waals bonding and hydrogen bonding. Most attention in this category has been placed on phosphate-bonded ceramics because they are amenable to the formation of strong ceramics at room temperature.

Ceramicists at ANL investigated the application of the chemically bonded phosphate ceramics to various mixed waste streams under the support of the Mixed Waste Focus Area of DOE. Innovative use of the ceramic in both micro- and macro-encapsulation techniques is being studied at ANL-W to make low-level wastes from mixed radioactive-hazardous wastes. ANL-W is investigating the applicability of chemically bonded phosphate ceramics to the more problematic mixed waste stream of high-Pu residues. Primary emphasis of the study is demonstration of stabilization, with subsequent characterization of gas generation and investigation of the recoverability of actinides.

ACCOMPLISHMENTS

CBPC has yielded results with low-level mixed wastes varying from soils and fine debris to ash. Without exception, the technology has bound heavy-metal laden wastes into monoliths that passed leachability potential tests for metals. Even difficult metals such as mercury were stabilized.

BENEFITS

CBPC produces strong stable monoliths at room temperature. Compressive strengths and leach resistance of the monoliths are greater than typical hydraulic cements. CBPC also chemically fixes metals in low-solubility phosphate compounds simulating naturally-occurring metal-containing phosphate ores. Mixing times are 30 minutes followed by 2 hours of solidification and multiple days of curing to reach full strength.

The CBPC stabilization process for residues has the potential to replace some thermal processes and it has no off-gas streams or secondary wastes. Stabilization takes place at room temperature at a scale of industrial kitchen equipment. The binders used in the process cost less than a dollar per pound. CBPC is a nonthermal technology that has the potential to be an economical approach in meeting residue stabilization needs.

COLLABORATION/TECHNOLOGY TRANSFER

Work with Pu-bearing residues is an extension of the effort by ANL on mixed wastes. Similar applications of phosphate bonding have been commercialized. No commercialization as a direct spin-off of the research has yet taken place.

CONTACTS

David B. Barber
Technology Development Division
Argonne National Laboratory - West
Post Office Box 2528
Idaho Falls, Idaho 83403-2528
(208) 533-7435
e-mail: dave.barber@anl.gov

Arun S. Wagh
Energy Technology Division
Argonne National Laboratory - East
9700 S. Cass Avenue
Argonne, Illinois 60439
(630) 252-4295
e-mail: arun_wagh@qmgate.anl.gov

3.0 New Technology Research and Development White Paper Evaluation

Objective

PFA must identify and recommend solutions to issues associated with plutonium stabilization and storage by encouraging industry and university participation in technology development. PFA calls for research proposals or "white papers." The process and criteria for evaluating white papers are explained in this section to facilitate successful submissions by researchers and increase the probability that the research will be accepted.

Process

PFA is chartered to evaluate as many as 50 white papers each fiscal year. PFA must provide a recommendation on whether to fund the research to the NMSTG or the researcher. The objectives of the evaluation procedure are to:

- facilitate acceptance of relevant white papers
- efficiently and fairly evaluate white papers
- keep researchers informed of the status and progress of their submissions

The following information is defined in this section to assist researchers be aware of specific acceptance criteria:

- evaluation process description
- contact to whom papers are to be submitted
- format
- evaluation criteria the white paper should address

Evaluation Process Description

The process is implemented by the organizations shown in Figure 3.0-1. The process includes the functions of solicititation, reception, and evaluation of white papers. The process is executed by the PFA manager, the PFA technical manager, the TAP, and associated staff.

TAP, with the acknowledgment of the PFA manager, may contact the researcher for clarification of information in the white paper. The requirements for fairly and efficiently evaluating white papers are met by the process steps of the procedure discussed in the next section.

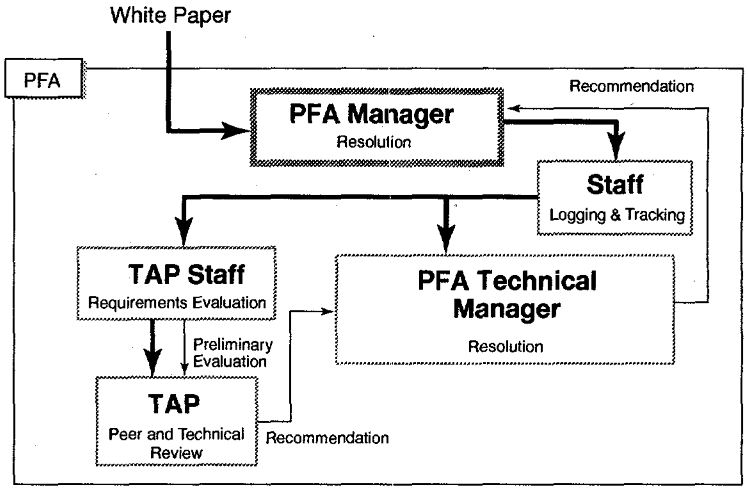

Figure 3.0-1. White papers are reviewed by PFA Manager, PFA Technical Staff, and TAP.

CONTACT

William L. Scott
U.S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, ID 83401-1562
Phone: (208) 526-8189
e-mail: scottwl@inel.gov

FORMAT FOR WHITE PAPERS

White papers shall be submitted in a format similar to the following outline and shall be no more than eight pages.

Part I. Research Summary
Name/Title of Research
Name/Title of Researcher(s)/Organization (Company, Lab or University) Affiliation(s)
Purpose of Research
Technology requirement(s) addressed in research are specifically based on:

- The indicated requirements from the PFA 1996 R&D Plan, November 1996 (provide a list), and/or
- The following requirements that are potentially viable to PFA (provide a list)

Summary of researcher's R&D activities and past white papers and Points of Contact: name, address, phone, fax, and e-mail address

Part II. Technical Description
Description of target problem
Description of proposed technology
Process or technology assessment

- Material end state(s), including waste streams
- Current technical status and maturity
- Need for further research and development

Technical maturity expected upon successful completion (see Appendix C of the R&D Plan for method of estimating technical maturity)

Part III. Research/Task Plan
Objective(s)
Task Descriptions
Scope: Sites, materials, and time frame to which research applies
Deliverables
Estimate of Cost and Schedule

Part IV. Researcher Qualifications
Resume of Researcher
Summary List of Publications of Researcher

Evaluation Criteria

White papers and supporting documentation submitted to PFA are logged and pre-screened by PFA and TAP staff before evaluation. Pre-screening consists primarily of a systems engineering review. Technical requirements addressed by the white paper will be evaluated against requirements in the 1996 R&D Plan, the Baseline Research and Development Technical Requirements Document, and 94-1 Implementation Plan milestones.

TAP Staff Requirements Evaluation Criteria

The purpose of screening is to determine that the white paper complies with requirements for format and content. The screening allows assessment of the relevance of proposed research to specific needs and requirements. Evaluation includes the following:

- Material type(s) to which the proposed research applies
- Quantities of materials to which the proposed research applies
- Other materials to which the proposed research might apply
- Stabilization or remediation processes involved
- End condition of materials resulting from application of research
- Deliverables of proposed research (such as reports or process flow sheets)

- Other useful products of research
- DOE site(s) to which the proposed research applies
- Research and development need date to which the proposed research applies
- Competing alternative technologies
- Current funding level of the proposed research
- Organization(s) currently funding the research
- Amount of EM funding already applied to this research
- Technical maturity
- Technical maturity and name of competitive alternative
- Resulting technical maturity if proposed research and development is successful
- Expected PFA trade study performance measure comparisons with baseline process (expressed as a % of baseline process or competitive alternative)

PFA trade study performance measures evaluation includes an estimation by PFA staff of 20-year-life-cycle costs resulting from an analysis of the technology applied to storage or disposition of relevant materials. The analysis uses the same flowsheets and assumptions used by respective trade studies.

TAP Evaluation Criteria

Evaluation by TAP is intended to allow assessment of the technical merit of proposed research. The review will consider the following:

- how well the proposed research and development addresses research and development technical requirements and 94-1 Implementation Plan milestones
- material end state(s) resulting from application of the proposed technology
- quantity and type of waste streams generated
- advances in technical maturity of the technology to be gained by the proposed work
- qualifications of research facilities for successfully executing the research and development
- barriers and implications to worker and public safety of the proposed technology

- potential for implementing the technology for stabilization of materials of other than those identified in the white paper (e.g., at other sites)
- the degree to which private or industrial participation is included in the technology development plan
- implications for stakeholder relations arising from the proposed research and development or its implementation
- researcher(s) qualifications (education and experience)
- facility and equipment

4.0 BUSINESS OPPORTUNITIES

PFA mechanisms to identify, integrate, develop, and adapt promising technologies include collaborative research and development agreements and subcontracts. PFA's procurement mechanisms for technology development are in the form of calls for white paper research proposals and formal solicitations. DOE contractor-operated laboratories can license PFA developed Pu stabilization technology. Licensing activities are conducted according to existing DOE intellectual property provisions.

Personnel exchanges provide opportunities for scientists from private industry and DOE laboratories to work together at various sites on focus area task assignments. Private industry is required to contribute cost-sharing for these personnel exchanges. To encourage such collaboration, a patent waiver gives ownership of any inventions resulting from the research to the participating private sector company.

CONTACTS

William L. Scott
U. S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, ID 83401-1562
Phone: (208) 526-8189
e-mail: scottwl@inel.gov

Dr. Bob Seidel
Argonne National Laboratory
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-2769
e-mail: bob.seidel@anl.gov

Dr. Finis H. Southworth
Idaho National Engineering
and Environmental Laboratory
Lockheed Martin Idaho
Technologies Company
2525 Fremont Avenue
P.O. Box 1625
Idaho Falls, ID 83415-3750
Phone: (208) 526-8150
e-mail: fin@inel.gov

BIBLIOGRAPHY OF KEY PUBLICATIONS

Aumeier, S. E., B. G. Walters, D.C. Crawford, R.C. Singleterry, G. Bushnell, T. Totemeier, T. Ewing, B. Motes, S.D. Hartenstein, D.K. Kotter, M.W. Walrath, and T. Lee. "Integrated Monitoring and Surveillance System Demonstration Project: Phase I Report," Argonne National Laboratory Report ANL/ED/971Y (1997).

Aumeier, S. E., B.G. Walters, B. Motes, S.D. Hartenstein, D.K. Kotter, and W.M. Walrath, "Integrated Monitoring and Surveillance System Demonstration Project," Submitted for presentation/publication in Proc. INMM 38th. Annual Meeting, July 1997.

Brown-Van Hoozer, A., R. M. Erickson, C. R. Kenley, and D. R. Schilling. *Procedure: Evaluation of New Technology Research and Development White Papers*, January 1977, PFA, PFA-TM-142d.

Charter of the PFA as attachment to memorandum from T. P. Grumbly (Ass't. Sec. USDOE) to J. M. Wilcynski (Manager DOE-ID) entitled "PFA," dated 2 October 1995, Washington, D.C.

Fewell, T. E., *Radioactive Scrap Metal Conversion into 3013 Storage Containers*, Lockheed Martin Idaho Technologies Company, November 1996, PFA-TM-624.

"Research and Development Plan," Rev.1 DOE/ID-10561, dated November 1996, Idaho Operations Office of the U.S. Department of Energy, Idaho Falls, Idaho 83402: http://www.inel.gov/national/pfa/documents/r&dplan.pdf

Roy, D.M. "New Strong Cement Materials: Chemically Bonded Ceramics," *Science*, 235, pp. 651-658, 1987.

Sakar, A.K. "Phosphate Cement-Based Fast-Setting Binders," *Ceramic Bulletin*, 69(2), pp. 234-238, 1990.

Schilling, D. R. and D.J. Johnson. *Baseline Research and Development Technical Requirements Document*, Lockheed Martin Idaho Technologies Company, PFA-TM-144A (25 March 1996): http://www.inel.gov/national/pfa/documents/brdtrd.pdf

Schilling, D. R., *Requirements Document for Fabrication of Prototype Containers from Radioactive Scrap Metal* (RSM) *to meet draft* DOE-STD-3013-96, 11/1966, PFA-TM-611.

U.S. Department of Energy, PFA, *Ash Residues End State Trade Study*, DOE/ID-10560, (February 28, 1995).

U.S. Department of Energy. *Nuclear Materials Stabilization Task Group Research Committee, Research and Development Plan* (November 1995).

ACRONYMS

ANL	Argonne National Laboratory
ANL-W	Argonne National Laboratory - West
BNFL	British Nuclear Fuels Limited
CBPC	Chemically Bonded Phosphate Ceramics
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DOE-ID	Department of Energy - Idaho Operations Office
DOE-MD	Department of Energy - Office of Fissile Materials Disposition
DOE-RW	Department of Energy - Office of Civilian Radioactive Waste Management
DOT	Department of Transportation
EM	Environmental Management
EPA	Environmental Protection Agency
GMODS	Glass Material Oxidation and Dissolution System
HAN	Hanford
HLW	High-Level Waste
HLWR	High-Level Waste Repository
IAEA	International Atomic Energy Agency
IMSS	Integrated Monitoring Surveillance System
INEEL	Idaho National Engineering and Environmental Laboratory
IP	DNFSB Recommendation 94-1 Implementation Plan
IX	Ion Exchange
LANL	Los Alamos National Laboratory
LCC	Life-Cycle Cost
LLNL	Lawrence Livermore National Laboratory
LLW	Low-Level Waste
LMITCO	Lockheed Martin Idaho Technologies Company
LOI	Loss On Ignition
MEO	Mediated Electrochemical Oxidation

MPPF	Multi-Purpose Processing Facility
MSE	Molten Salt Extraction
MSRE	Molten Salt Reactor Experiment
NEPA	National Environmental Policy Act
NMSO	Nuclear Materials Stabilization Office
NMSTG	Nuclear Materials Stabilization Task Group
NRC	Nuclear Regulatory Commission
NSR	New Special Recovery Facility at SRS
OCRWM	Office of Civilian Radioactive Waste Management
ONMFS	Office of Nuclear Material and Facility Stabilization
ORNL	Oak Ridge National Laboratory
PFA	Plutonium Focus Area
PuSPS	Plutonium Stabilization and Packaging System
PVC	Polyvinyl Chloride
QA	Quality Assurance
RC	Research Committee
RCRA	Resource Conservation and Recovery Act
R&D	Research and Development
RDP	Research and Development Plan
RFETS	Rocky Flats Environmental Technology Site
RSM	Radioactive Scrap Metal
SEG	Scientific Ecology Group
SRS	Savannah River Site
SS&C	Sand, Slag, and Crucible
TAP	Technical Advisory Panel
TRD	Technical Requirements Document
TRU	Transuranic
TRUW	Transuranic Waste
WAC	Weapons Acceptance Criteria
WIPP	Waste Isolation Pilot Plant

☆ U.S. GOVERNMENT PRINTING OFFICE: 1997 433-460/20026