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Vol. II

TECHNICAL AREA STATUS REPORT FOR LOW-LEVEL MIXED WASTE FINAL WASTE FORMS

Volume II
APPENDICES

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ACRONYMS

°C	degrees centigrade
°F	degrees Fahrenheit
ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AVM	Ateliers de Vitrification de Marcoule
BNL	Brookhaven National Laboratory
BNWL	Battelle Northwest Laboratory
BWR	Boiling Water Reactor
CFR	Code of Federal Regulations
CIF	Consolidated Incineration Facility
CRT	cathode ray tube
DOE	Department of Energy
DOT	Department of Transportation
DWPF	Defense Waste Processing Facility
EDTA	Ethylene Diamine Triacetic Acid
EP	Extraction Procedure
EPA	Environmental Protection Agency
FWF	Final Waste Form
HEME	High Efficiency Mist Eliminator
HEPA	High Efficiency Particulate Air
HLRW	High Level Radioactive Waste
HLW	High Level Waste
HWTF	Hanford Waste Treatment Facility
IAEA	International Atomic Energy Agency
ICPP	Idaho Chemical Processing Plant
ID	inner diameter
IFR	Integral Fast Reactor
INEL	Idaho National Engineering Laboratory
ISV	In Situ Vitrification
LANL	Los Alamos National Laboratory
LDPE	Low Density Polyethylene
LLMW	Low Level Mixed Waste
LLW	Low Level Waste
LLRW	Low Level Radioactive Waste
LOMI	Low Oxidation State Metal Ion
MCC	Material Characterization Center
MW	Mixed Waste
MWIP	Mixed Waste Integrated Program
MWTP	Mixed Waste Treatment Program
N/A	Non-applicable
NDT	Non-destructive Testing

NRC	Nuclear Regulatory Commission
OTD	Office of Technology Development
PCB	Polychlorinated Biphenyls
PCC	Portland Cement Concrete
PCT	Product Consistancy Test
PNL	Pacific Northwest Laboratory
PWR	Pressurized Water Reactor
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act
RFP	Rocky Flats Plant
SA/V	surface area over volume
SLS	Soda-Lime-Silicate
SPC	Sulfur Polymer Cement
SRL	Savannah River Laboratory
SRP	Savannah River Plant
SRS	Savannah River Site
TASR	Technical Area Status Report
TBP	Tributyl Phosphate
TCLP	Toxicity Characteristic Leaching Procedure
TRU	transuranic
UF	Urea Formaldehyde
VES	Vinyl-Ester Styrene
VRS	Volume Reduction and Solidification
WERF	Waste Experimental Reduction Facility
WG	Working Group
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WSRC	Westinghouse Savannah River Company
WVDP	West Valley Demonstration Project

NOMENCLATURE

Ag	silver
Al	aluminum
Al_2O_3	aluminum trioxide
$AlPO_4$	aluminum phosphate
Am	americium
As	arsenic
B	boron
B_2O_3	boron trioxide
Ba	barium
Be	beryllium
Br	bromine
BTU	British Thermal Units
Ca	calcium
CaO	calcium oxide
Cd	cadmium
Cl	chlorine
Co	cobalt
CO	carbon monoxide
CO_2	carbon dioxide
CoS	cobalt sulfide
CoSe	cobalt selenide
Cr	chromium
CrO_2	chromium dioxide
Cs	cesium
Cu	copper
Eh	electro-chemical potential
F	fluorine
Fe	iron
Fe_2O_3	iron trioxide
g/cm^2	grams per square centimeter
gpm	gallons per minute
H_2	hydrogen
H_2SO_4	sulfuric acid
Hg	mercury
HNO_3	nitric acid
hp	horsepower
hr	hour
kg	kilogram
kW	kiloWatt
lb	pound
Li	lithium
MGy	millions of Gray (100 rems)

Mn	manganese
MnO	manganese xide
Mo	molybdenum
MPa	megaPascal
mph	miles per hour
Na	sodium
NaCl	sodium chloride
NaK	sodium potassium
$NaNO_3$	sodium nitrate
Na_2O	sodium oxide
Ni	nickel
NiS	nickel sulfide
NiSe	nickel selenide
NiTe	nickel teluride
NL	normalized log
NO	nitrogen oxide
Np	neptunium
Pb	lead
PbI_2	lead iodide
$Pb_3(PO_4)^2$	lead phosphate
PO_4	phosphate
psi	pounds per square inch
Pu	plutonium
Ru	ruthenium
scfm	standard cubic feet per minute
Sb	antimony
Se	selenium
Si	silicon
SiO_2	silica
SO_2	sulfur dioxide
SO_4	sulfate
Sr	strontium
SrO_3	strontium trioxide
Tc	technetium
TiO_2	titanium dioxide
U	uranium
V	vanadium

INTRODUCTION

The descriptions of the low-level mixed waste (LLMW) streams that are considered by the Mixed Waste Integrated Program (MWIP) are given in Appendix A. This information was taken from descriptions generated by the Mixed Waste Treatment Program (MWTP). Appendix B provides a list of characteristic properties initially considered by the Final Waste Form (FWF) Working Group (WG). A description of facilities available to test the various FWFs discussed in Volume I of DOE/MWIP-3 are given in Appendix C. Appendix D provides a summary of numerous articles that were reviewed on testing of FWFs. Information that was collected by the tests on the characteristic properties considered in this report are documented in Appendix D. The articles reviewed are not a comprehensive list, but are provided to give an indication of the data that are available.

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APPENDIX A
LLMW CHARACTERIZATION CODE DESCRIPTIONS

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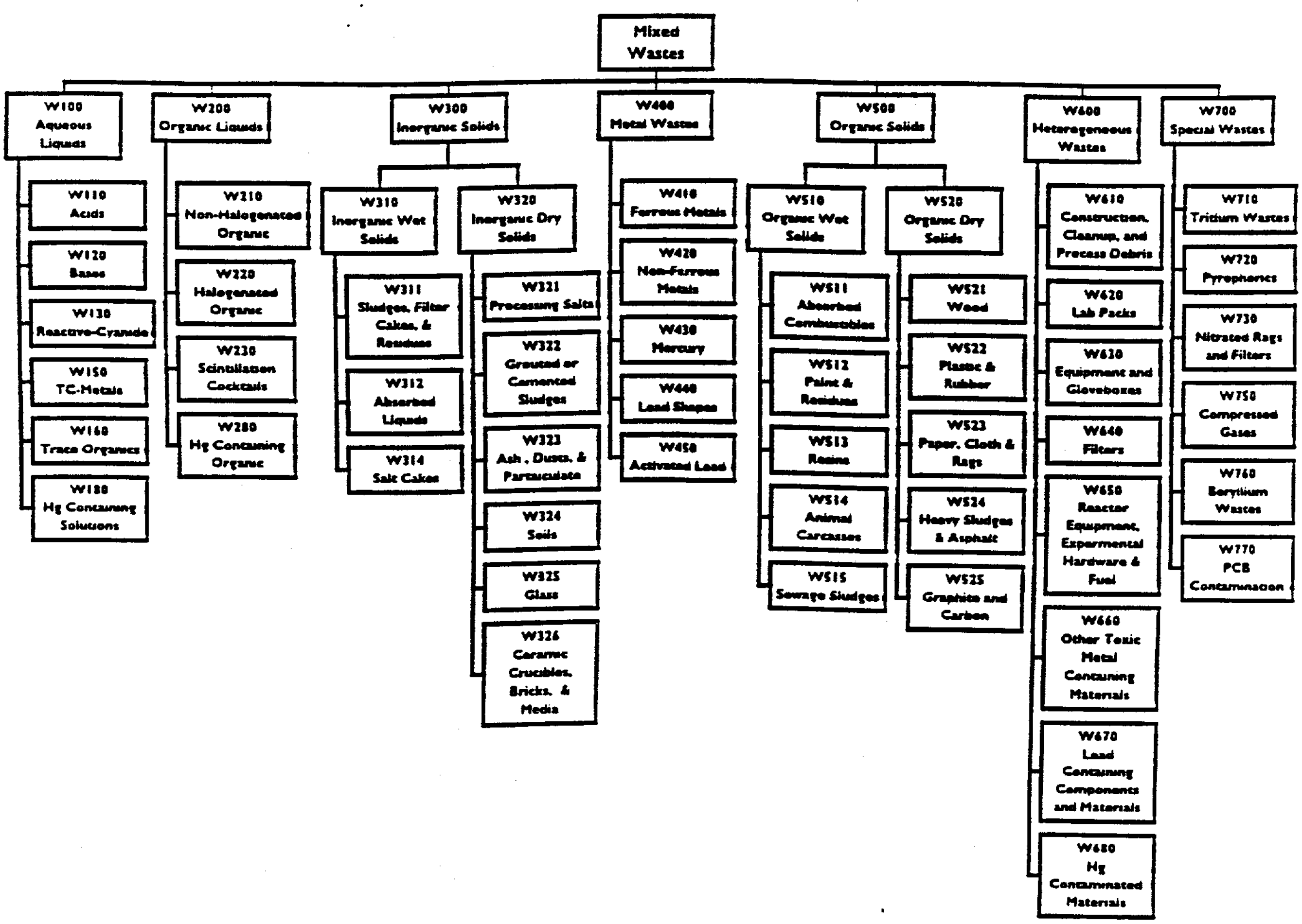
Wayne Ross at PNL has developed the following waste code descriptions for the Mixed Waste Treatment Project sponsored by DOE EM-30. The descriptions include LLMW streams from some of the DOE sites that store or generate LLMW. The waste has been divided into seven general waste categories and 52 subcategories. See figure below for a matrix of the categories described herein.

Fig. A-1. Mixed waste matrix characterization categories



CODE #	TITLE	DESCRIPTION
W100	Aqueous Liquids	Aqueous solutions with less than 1% organic content. Solids must be pumpable but can be up to about 35-40% of the mass. Wastes in this specific category could not be assigned to a subcategory because of lack of information or because of multiple characteristics of the waste stream. Streams contain some of the following: As, Cd, Cr, Pb, Hg, and Ag. Contains trace hazardous organics.
W110	Corrosive acids	Principle sources of these wastes are general waste water cleanup, plating line solutions, and electropolishing activities. Streams contain some of the following: Cr, Pb, Hg, and Ag. Contains trace hazardous organics.
W120	Corrosives Bases	These are solutions with a high pH generated from a variety of activities. Streams contain some of the following: As, Cd, Cr, and Pb.
W130	Reactive-Cyanide	Any stream that contains cyanide as a significant component. Solutions will generally be basic. Streams contain some of the following: As, Cd, and Cr.
W150	TC-Metals	Streams containing toxic metals. Streams contain some of the following: Cd, Cr, Pb, Hg, and Se. Contain trace hazardous organics.
W160	Trace Organics	Streams with organic levels of less than 1%. Some streams also contain some lead.
W180	Hg Containing Solutions	Any of the 100 series solutions that may contain Hg. Streams may also contain some lead.
W200	Organic Liquids	Liquid streams containing more than 1% organic. Solids must be pumpable (except for code 230) but can be comprise of up to about 35-40% of the mass. Wastes in this specific category could not be assigned to any subcategory because of lack of information.
W210	Non-Halogenated Organics	Solvents free of F, Cl, Br, (e.g. oils, hexone, methanol). Wastes may contain Cd, Cr, Pb, Hg, and Se as trace contamination.

CODE #	TITLE	DESCRIPTION
W220	Halogenated Organics	Solvents containing F, Cl, Br, etc. Contaminated freon is one specific stream. Streams may contain Cd, Cr, Pb, Hg, and Ag as trace contaminants.
W230	Scintillation Cocktails	Solutions used for scintillation counting. Solutions may be contained in the original glass or plastic analysis bottles. Streams may contain Cd, Cr, and Pb as trace contamination.
W280	Hg Containing Organics	Any 200 series waste that may contain Hg. Streams may contain Se as a trace contaminant.
W300	Inorganic Solids	This category includes all inorganic solids except metal wastes. The inorganic materials are generally oxides, but also include salts. The major category is divided into wet solids, dry solids, and soils.
W310	Wet Inorganic Solids	A solid mass, non pumpable, that contains liquids within the pore structure of the solid. Liquid fractions should be more than 5% of the mass of the material. Wastes in this specific category could not be assigned to any subcategory because of lack of information.
W311	Sludges, Filter Cakes and Residues	These materials are generally from wastewater cleanup or from settling ponds. They may contain organic materials in limited quantities from laundry or other sources. Heavy metals are present in some sludges. Cemented sludges are W322 wastes. Streams may contain Ba, Cd, Cr, Pb, Hg, Ag, V, and cyanide as trace contamination. Contains trace hazardous organics.
W312	Absorbed Liquids	Aqueous or organic liquids absorbed onto a solid such as vermiculite or clay.
W314	Salt Cakes	Evaporated salt solutions, either nitrate and chloride, that may contain a high residual water content. Streams may contain Ba as trace contamination.

CODE #	TITLE	DESCRIPTION
W320	Inorganic Dry Solids	Inorganic solids without notable free liquid. Most wastes will contain some combined water or absorbed water. Liquid fractions will generally be less than 5% of the mass of the material. Wastes in this specific category could not be assigned to any subcategory because of lack of information. Streams may contain As, Ba, Pb, and Se as trace contamination. Contains trace hazardous organics.
W321	Processing Salts	Salts that have been used in processing; mostly F, Cl, NO_3 based salts. Streams may contain As, Ba, Cd, Cr, Pb, and Se as trace contamination. Contains trace hazardous organics.
W322	Grouted or Cemented Sludges	Sludges that contain cement either as a water absorber or that are mixed with cement to produce a homogenous solid waste. Streams may contain Cd, Cr, and Pb as trace contamination. Contains trace hazardous organics.
W323	Ash, Dusts, and Particulates	Fine particulate wastes. Typical wastes are ash from incinerators, dusts, and paint chips. Cemented particulates are included in code W322. Streams may contain As, Cd, Cr, Pb, Ag, and Se as trace contamination. Contains trace hazardous organics.
W324	Soils	Contaminated soils from spills, leaks, cleanups, and waste burial. Streams may contain As, Ba, Cd, Cr, Pb, Hg, Ag, and Se as trace contamination. Contains trace hazardous organics.
W325	Glass	Items composed primarily of glass, including process equipment, laboratory equipment, window materials, vessels, bottles, light bulbs, or glass beads or forms used within process equipment or for abrasion of surfaces. The glass may contain small amounts of organic or other inorganic materials. Streams may contain Ba, Cd, Pb, and Hg as trace contamination. Contains trace hazardous organics.
W326	Ceramic, Crucibles, Bricks and Media	Oxide materials generally used as crucibles or refractories. They may also be beads or shapes used for catalysts, reactor beds, or for milling or grinding. Streams may contain As, Cr, Pb, Hg, and Ag as trace contamination. Contains trace hazardous organics.

CODE #	TITLE	DESCRIPTION
W400	Metal Wastes	Inorganic solids classed as metals. This category includes wastes that are mixed ferrous and nonferrous metals or other defined metals. Streams may contain Cd, Cr, Pb, and Hg as trace contamination. Contains trace hazardous organics.
W420	Nonferrous Metals	Nonferrous metals are the principle component, such as aluminum, copper, and cadmium. May have trace Pb contamination.
W430	Mercury	Liquid mercury pourable from containers.
W440	Lead Shapes	Lead bricks, shipping casks, or shielding materials. The lead should only be surface contaminated. May have some Cr contamination. Contains trace hazardous organics.
W450	Activated Lead	Lead activated from its use in radiations fields, such as from a reactor or accelerator.
W500	Organic Solids	Waste streams that are predominately organic materials and candidates for direct treatment most likely by incineration. Wastes that are mixtures of the various subcategories or undefinable beyond this category are included.
W510	Organic Wet Solids	These are organic solids that have significant content of liquids generally combined with the waste matrix. Streams may contain As, Ba, Cd, Cr, Pb, Ag, and Se as trace contamination.
W511	Absorbed Combustibles	Rags or paper used to wipe up spills. Organic liquid spill cleanup materials. Streams may contain Ba, Cr, Pb, and Se as trace contamination. Contains trace hazardous organics.
W512	Paint and Residues	New or removed paint. The paint may be liquid or have a liquid content either as original paint or a paint stripper. It may also only be paint chips. Streams may contain As, Ba, Cr, Pb, and Hg as trace contamination. Contains trace hazardous organics.

CODE #	TITLE	DESCRIPTION
W513	Resins	Spent organic resins including spent carbon filters used in waste water cleanup. Streams may contain As, Ba, Hg, Ag, and Se as trace contamination. Contains trace hazardous organics. Some resins are not compatible with cement or grout systems.
W514	Animal Carcasses	Dead animals or parts of animals. Most animals will have been used in testing and may contain agents to stabilize the remaining materials. Streams may contain As, Ba, Hg, Ag and Se as trace contamination.
W520	Organic Dry Solids	These are organic solids that do not have significant content of liquids. Streams that may contain a variety of solid organic wastes such as mixtures of wood, plastic, and paper. Streams may contain Ba, Cd, Pb, and Ag as trace contamination. Contains trace hazardous organics.
W521	Wood	Wood timbers used for packaging or temporary structures similar to construction debris, however this would be wood as the single principle component. Some noncombustible tramp materials such as nails is to be expected in concentrations of less than 5%.
W522	Plastic and Rubber	Plastic sheeting or components such as benelex or plexiglass. It also includes glovebox gloves. Leaded gloves would be included in W670, but this stream may include trace Pb. Contains trace hazardous organics.
W523	Paper, Cloth, and Rags	Contaminated clothing and wipes. May include traces of metals. Streams may contain As, Ba, Cd, Cr, Pb, Hg, and Ag as trace contamination. Contains trace hazardous organics.
W524	Heavy Sludges and Asphalt	Heavy sludges are organic based materials that have such high viscosity that they can not be poured from a drum. Asphalt roadways or walkways that become contained with radioactivity. It would contain rock and organic binders. Streams may contain Cr, Pb, Hg, Ag, and Se as trace contamination. Contains trace hazardous organics.
W525	Graphite and Carbon	Crucibles or components of graphite or carbon.

CODE #	TITLE	DESCRIPTION
W600	Heterogeneous Wastes	Solid materials that may contain a mixture (either as manufactured or from packaging) of organic, inorganic solid, and/or metallic materials. Wastes in this specific category could not be assigned to any subcategory because of lack of information or because they are a mixture of other waste types. Streams may contain Cd, Cr, Pb, Se and Ag as trace contamination. Contains trace hazardous organics.
W610	Construction, Cleanup, and Process Debris	Construction debris is generated from the remodeling of radioactive facilities and could include piping, wiring, wall materials, and flooring. Also includes wood and plastic sheeting used for temporary radioactive particulate containment and cleanup and process debris that are mixtures of various types of material that were commingled for disposal. A mixture of combustible organic, metal, and ceramic materials. Streams may contain As, Ba, Cd, Cr, Pb, Hg, Se and Ag as trace contamination. Contains trace hazardous organics.
W620	Lab Packs	Mixtures of chemical in drums. Chemicals are mostly solid, but can contain liquids. Packing materials such as vermiculite are commonly included. Streams may contain As, Ba, Cd, Cr, Pb, Hg, and Se as trace contamination. Contains trace hazardous organics.
W630	Equipment and Gloveboxes	Process equipment generally metallic, but that may contain oils, grease, or process materials. The equipment may include some associated electrical wiring and piping. Packaged gloveboxes that may contain equipment, windows, gloves, and other organic materials. They may also be contaminated with oils or sludges. Since many gloveboxes have been used with TRU materials some level of alpha contamination may be expected. Leaded gloves may be present. Streams may contain Cr and Pb as trace contamination.

CODE #	TITLE	DESCRIPTION
W640	Filters	HEPA filters, and other process filters that may be metallic, organic or ceramic are included. Filters are contaminated with fine particulate. HEPA filters may be either wood or metal frame. Streams may contain As, Ba, Cd, Cr, Pb, Hg, Se and Ag as trace contamination. Contains trace hazardous organics.
W650	Reactor Equipment, Experimental Hardware and Fuel	Reactor equipment may contain listed chemicals and toxic metals. They can become highly radioactive during neutron irradiation in reactors. These materials may need special care as they contain activated metals and radiation that can not be removed by decontamination. Streams may contain As, Cd, Pb, and Hg as trace contamination. Contains trace hazardous organics.
W660	Other Toxic Metal Containing Materials	As, Ba, Cd, Cr, Se, and Ag contaminated materials. Lead may be present as a trace contamination. Contains trace hazardous organics.
W670	Lead Containing Components and Materials	Glovebox gloves or shielding aprons containing lead or lead oxide in a rubber or plastic binder, which includes lead acid batteries. May also be lead wool or lead base solder materials.
W680	Hg-Contaminated Materials	Materials contaminated with Hg. Materials may be of any general type. Streams may contain Ba, Cd, Cr, Pb, Se and Ag as trace contamination.
W700	Special Wastes	These are waste streams that will require extra care for treatment. They may require specific treatment equipment or processes not consistent with current radioactive materials handling guidance.
W710	Tritium Wastes	Waste streams contaminated with tritium. They may be liquid or solids. Streams may contain Cr and Hg as trace contamination. Contains trace hazardous organics.
W720	Pyrophorics	Reactive metals. They are typically sodium metal or sodium metal alloys, but can also be particulate fines of aluminum, uranium, beryllium, zirconium, or other pyrophoric materials and may be mixed with reaction preventing materials.

CODE #	TITLE	DESCRIPTION
W730	Nitrated Rags and Filters	Rags that have been used to absorb nitric acid and then been left in storage.
W750	Compressed Gases	Aerosol cans and gas cylinders of any type of composition.
W760	Be Wastes	Be metal chips, dusts, or materials contaminated with Be. Contains trace hazardous organics.
W770	PCB Contamination	Solids and liquids contaminated with PCBs. A wide range of material types. Streams may contain Cr and Pb as trace contamination.

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APPENDIX B
FINAL LIST OF PERTINENT FINAL WASTE FORM CHARACTERISTICS

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One of the activities of the Final Waste Form Working Group was to determine the characteristics that a final waste form should possess. A list of 21 pertinent waste form characteristics was initially generated, and is shown in Table B-1.

Table B-1. Initial List of Pertinent Final Waste Form Characteristics

Compressive Strength	Homogeneity	Handling
Thermal Stability	Particle Size	Melting Point
Radiation Stability	Chemical Durability	Solubility
Biological Stability	Compositional Flexibility	Volatility
Leach Resistance	Gas Generation	Criticality
Immersion Stability	Aging/Time Dependence	Void Fraction
Free Liquid	RCRA Compliance	Waste Loading

The above list of 21 characteristics was later revised to include only the eleven characteristics which are discussed in the TASR. Ten of the characteristics shown in Table B-1 were deleted due to redundancy, lack of methods for measurement, and inappropriateness considering the charter of the technical committee. A short description of these discarded characteristics and the rational for deleting them follows:

<u>Homogeneity</u> - This characteristic refers to the degree of homogeneity of the waste and the binder. Although this characteristic may be important when considering representative sampling and the characterization of the final waste form, it does not address performance.

<u>Particle Size</u> - This characteristic was originally included to prevent the possibility of respirable particles being present and thus creating safety issues during storage and handling. A baseline was established that would only include "monolithic" waste forms, thus restricting the physical form and removing the need for this characteristic. This requirement is indirectly included in the compressive strength characteristic.

<u>Aging/Time Dependence</u> - This characteristic refers to the long-term performance of the waste form. Although it is an important characteristic, it was felt that it was too broad and could be more effectively quantified by more specific characteristics such as chemical stability, and leach resistance.

<u>Handling</u> - This characteristic was included to address the safety issues and the physical considerations associated with handling the waste form. This characteristic is not considered a performance criteria.

<u>Melting Point</u> - This characteristic addresses the need for the waste form to maintain its physical dimensions and to remain in a solid form at high

temperature. This characteristic is important under accident conditions and is addressed by thermal stability.

Volatility - This characteristic refers to the generation of volatile species under normal storage and disposal conditions. It was felt that this characteristic was covered under the gas generation and RCRA non-characteristic criteria.

Criticality - This characteristic addresses the potential for formation of a critical mass. Based on the concentration limits established for LLW the potential for criticality does not exist.

Void Fraction - This characteristic is referred to in the NRC guidance for LLW. It is, however, a consideration that addresses structural stability and economics. It was felt that the stability requirement is covered by the retained characteristics; the economic concern is beyond the scope of this report.

Waste Loading - This characteristic refers to the ability of the binder to effectively isolate large quantities of waste. Although this is an important characteristic of the final waste form, it primarily effects the economics of the process and therefore was outside the scope of this report.

Solubility - This characteristic refers to the "equilibrium" concentrations of species in solution. It is a major factor in leach resistance and, for the purposes of this review, is included in that characteristic.

APPENDIX C
SUMMARY OF CURRENT STATUS

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GLASS

TITLE:	Electrically Heated Glass Melter Connected to a Wet Scrubber Offgas System
EQUIPMENT:	Joule-Heated Glass Melter
LOCATION:	EG&G Mound Applied Technologies Miamisburg, Ohio
CONTACT:	Larry Klingler: (513) 865-3078 EG&G Mound
CAPABILITIES:	Thermal Capacity -- 400,000 Btu/hr Temperature -- 730°C to 1,350°C Maximum Throughput -- N/A Treatable Waste -- RCRA hazardous and low-level radioactive wastes
VERSATILITY:	N/A
DESCRIPTION:	The system under study at Mound consists of an electrically heated glass melter connected to a wet offgas scrub system. The glass furnace was purchased from Penberthy Electromelt, Inc. The unit is equipped with feed systems designed to provide the flexibility to introduce a variety of waste types in accurately metered quantities.
OFFGAS SYSTEM:	The offgas system features a primary and secondary wet scrubbing by means of a spray tank and a high efficiency venturi scrubber. The scrubber system is followed by a cyclone demister and several stages of HEPA filtration. A scrub liquid recycling system provides caustic solution for the scrubbing operations.
STATUS:	Has operated but shutdown pending environmental assessment review.

GLASS

TITLE: High Bay Ceramic Melter

EQUIPMENT: Joule-Heated Melter

LOCATION: Hanford Site
Richland, WA

CONTACT: Chris Chapman: (509) 376-6576
Pacific Northwest Laboratory

CAPABILITIES: Thermal Capacity -- ~1,500,000 BTU/hr[1]
Temperature -- 1,200°C
Throughput -- Inorganic Solids: 570-710 kg/d; Combustibles: 850-
1,714 kg/d[1]; Slurries: 630-1,050 kg/d
Treatable Waste -- Non-radioactive RCRA hazardous waste

VERSATILITY: Waste feeding systems will handle slurries (acid, bases, neutral), sludges, solids (soils, combustible trash, tramp metals). Device is not suitable for wastes with large metal pieces.

DESCRIPTION: Melter has a cylindrical melt cavity 2 ft in diameter and is 2.83 ft deep with a flat floor. Reaction chamber above the melt can be maintained at temperatures up to 1,000°C with unit's plenum heaters. Unit has a batch bottom drain and a conventional bottom take off, overflow discharge. Melter is enclosed in a water cooled stainless steel jacket. Electrodes are side entering plates (2 sets) made of Inconel 690. The refractory lining is made of Monofrax K-3. Feed ports are 6-in. ID on the current lid. Larger sizes can be achieved with a new lid. Control and data logging equipment are associated with the system. The melter is shown in Figure C-1.

OFFGAS SYSTEM: 800 SCFM offgas treatment capacity
Submerged bed scrubbers
High efficiency mist eliminator (HEMEs)
Packed column
Hydrosonic scrubber

---

[1]Existing blower limits this to about 1,200,000 BTU/hr and 1,280 kg/d of 22,000 BTU/kg feed.

High pressure drop venturi scrubbers
Activated carbon absorption
High efficiency metal fiber filter
HEPA
Thermosyphon evaporator, concentrator

Offgas characterization equipment includes particulate size fraction characterization (0.3 to >10μm) and compositions. Volatile organics and gases with mass spectrometry.

STATUS: Current being upgraded for a new slurry feed system and an independent off gas system.

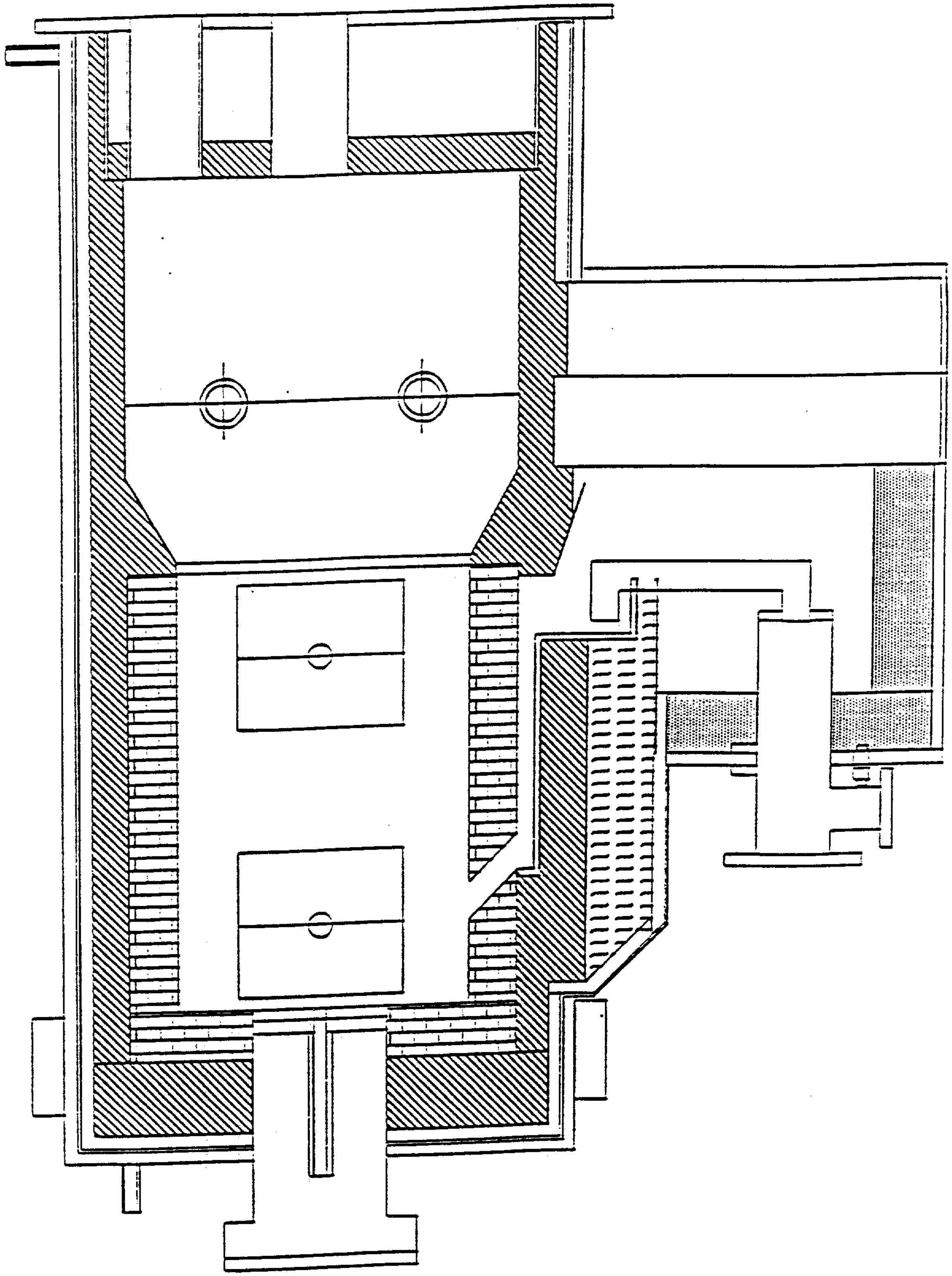

Fig. C-1. High bay ceramic melter

GLASS

TITLE:	Advanced Test Melter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Hanford Site Richland, WA
CONTACT:	Chris Chapman: (509) 376-6576 Pacific Northwest Laboratory
CAPABILITIES:	Thermal Capacity -- ~750,000 BTU/hr[1] Temperature -- 1,550°C Throughput -- Inorganic solids: 270-340 kg/d; combustibles: 400- 800 kg/d[1]; slurries: 300-500 kg/d Treatable Waste -- Non-radioactive RCRA hazardous waste
VERSATILITY:	Waste feeding systems will handle slurries (acid, bases, neutral), sludges, solids (soils, combustible trash, tramp metals). Devise is suitable for wastes with large metal pieces.
DESCRIPTION:	The Advanced Test Melter, shown in Figure C-2, has a rectangular cavity 1.5 ft long by 1 ft wide and is 1 ft deep with a flat floor. The unit has a controllable, freeze valve bottom drain and a conventual bottom take off, overflow discharge. There is a tilt pour mechanism for drain control. The melter is enclosed in a water cooled steel jacket. Electrodes are top entering molybdenum rods with oxidation resistant sheaths. Refractory lining is Monofrax K-3 and E. Feed ports are 6-in. ID on current lid. Larger sizes can be achieved with new lid. Control and data logging equipment are associated with the system.

[1]Existing blower limits this to about 1,200,000 BTU/hr and 1,280 kg/d of 22,000 BTU/kg feed.

OFFGAS SYSTEM:

800 SCFM offgas treatment capacity
Submerged bed scrubbers
HEMEs
Packed column
Hydrosonic scrubber
High pressure drop venturi scrubbers
Activated carbon absorption
High efficiency metal fiber filter
HEPA
Thermosyphon evaporator, concentrator

Offgas characterization equipment includes particulate size fraction characterization (0.3 to >10μm) and compositions. Volatile organics and gases with mass spectrometry.

STATUS:

Constructed but not in operation.

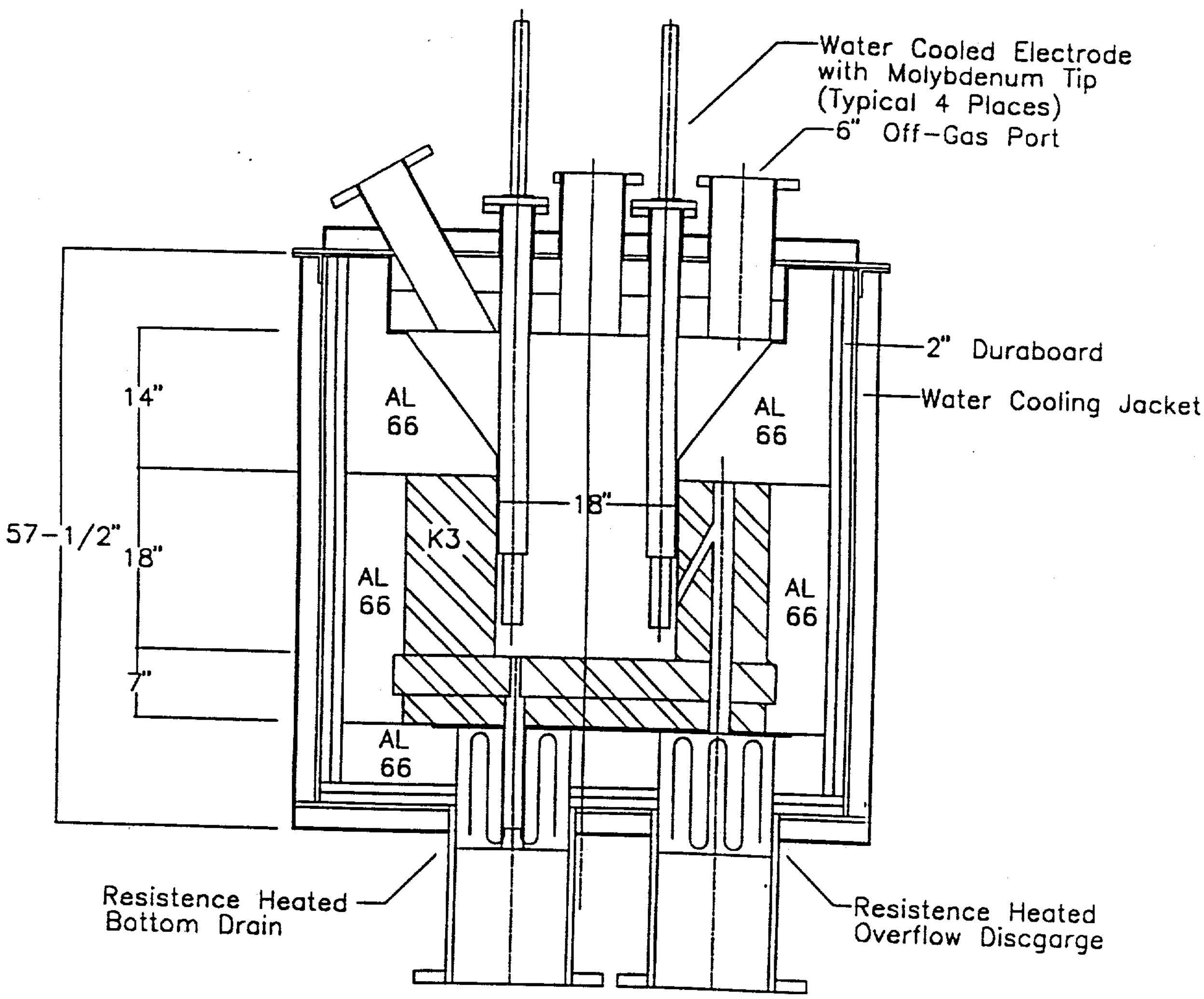

Fig. C-2. Advanced test melter (ATM)

GLASS

TITLE: High Temperature Melter

EQUIPMENT: Joule-Heated Melter

LOCATION: Hanford Site
Richland, WA

CONTACT: Chris Chapman: (509) 376-6576
Pacific Northwest Laboratory

CAPABILITIES: Thermal Capacity -- ~6,000,000 BTU/hr[1]
Temperature -- 1,550°C
Throughput -- Inorganic Solids: 3,800-4,700 kg/d; Combustibles: 5,700-11,400 kg/d[1]; Slurries: 4,200-7,000 kg/d
Treatable Waste -- Non-Radioactive RCRA Hazardous Waste

VERSATILITY: Waste feeding systems will handle slurries (acid, bases, neutral), sludges, and solids (soils, combustible trash, tramp metals). Device is suitable for wastes with large metal pieces.

DESCRIPTION: Melter has a cylindrical cavity 5.2 ft in diameter and is 3.5 ft deep with a sloped floor. Unit has a controllable, freeze valve, bottom drain and a conventional bottom take off, overflow discharge. Reaction chamber above melt can be maintained at a temperature up to 1,000°C with plenum heaters. Melter is enclosed in a water cooled stainless steel jacket. Electrodes are top entering, molybdenum rods (2 sets) with oxidation resistant sheaths. The refractory lining is made of Monofrax K-3 and E. Monofrax electrodes are also tested. Feed ports is up to 24-in. ID. Provision for a central arc boosting or high capacity joule electrode is present. Control and data logging equipment is associated with the system. A diagram of this melter is provided in Figure C-3.

[1]Existing blower limits this to about 1,200,000BTU/hr and 1,280 kg/d of 22,000 BTU/kg feed.

OFFGAS SYSTEM:	800 SCFM offgas treatment capacity Submerged bed scrubbers HEMEs Packed column Hydrosonic scrubber High pressure drop venturi scrubbers Activated carbon absorption High efficiency metal fiber filter HEPA Thermosyphon evaporator, concentrator Offgas characterization equipment includes particulate size fraction characterization (0.3 to >10μm) and compositions. Volatile organics and gases with mass spectrometry.
STATUS:	Under construction; due to be in operation 1st quarter of 1993.

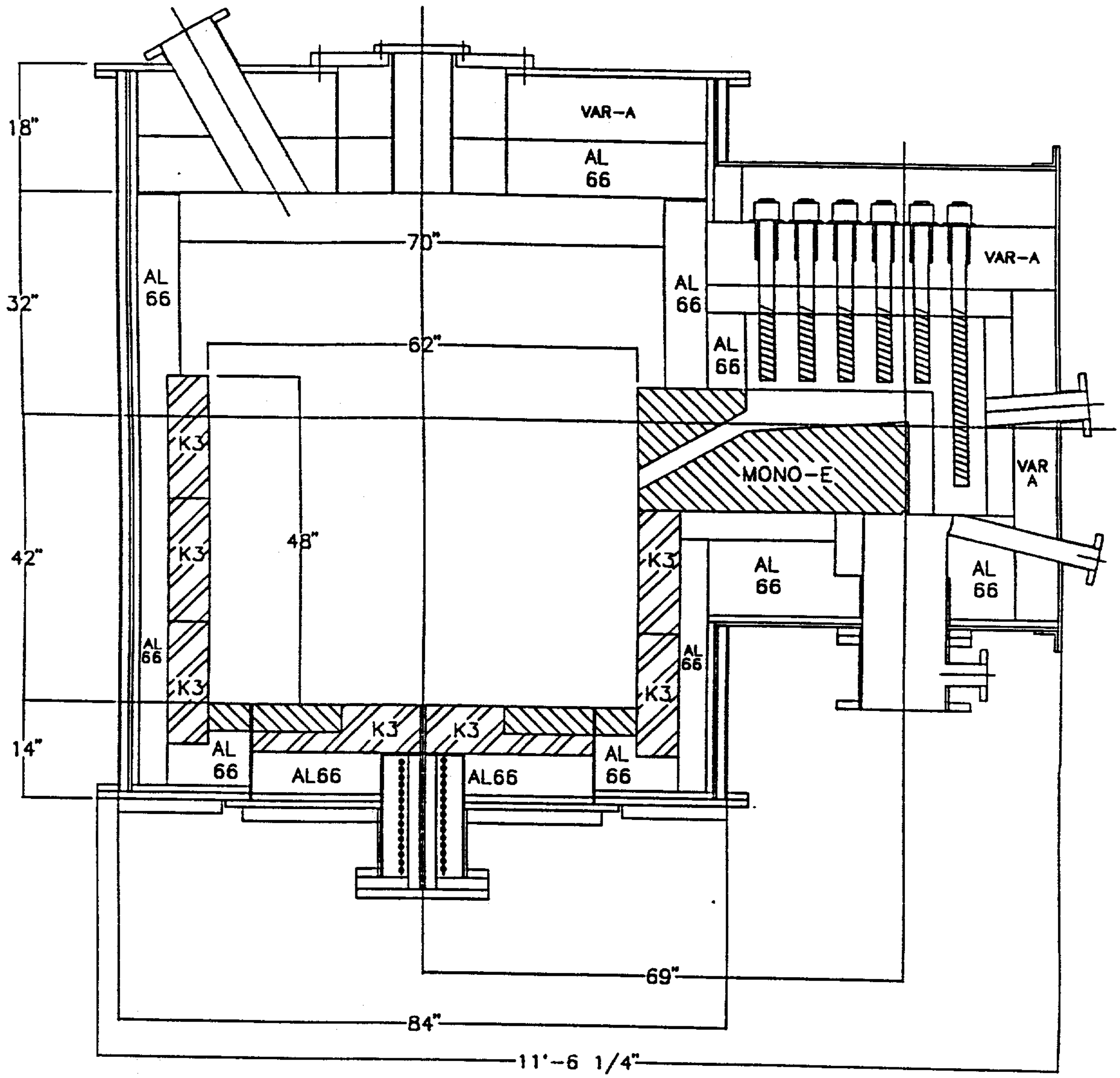

Fig. C-3. High temperature melter

GLASS

TITLE:	Liquid Fed Ceramic Melter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Hanford Site Richland, WA
CONTACT:	Chris Chapman: (509) 376-6576 Pacific Northwest Laboratory
CAPABILITIES:	Thermal Capacity -- ~5,600,000 BTU/hr[1] Temperature -- 1,200°C Throughput -- Inorganic solids: 2,000-2,500 kg/d; combustibles: 3,000-6,100 kg/d[1]; slurries: 2,250-3,750 kg/d Treatable Waste -- Non-radioactive RCRA hazardous waste
VERSATILITY:	Waste feeding systems will handle slurries (acid, bases, neutral), sludges, solids (soils, combustible trash, tramp metals). Device is not suitable for wastes with large metal pieces that can not be oxidized in the feed pile.
DESCRIPTION:	The Liquid Fed Ceramic Melter, shown in Figure C-4, has a rectangular melt cavity 4 ft long by 2.8 ft wide and 1.8 ft deep with a 46° sloped floor. Unit has a batch bottom drain and a conventional bottom take off, overflow discharge. Reaction chamber above melt can be maintained at a temperature up to 1,000°C with plenum heaters. The melter is enclosed in a water cooled stainless steel jacket. The electrodes are side and bottom entering plates (3 total) made of Inconel 690. The refractory lining is Monofrax K-3. Largest feed port is 10-in. diameter. Control and data logging equipment are associated with the system.

[1]Existing blower limits this to abcut 1,200,000 BTU/hr and 1,280 kg/d of 22,000 BTU/kg feed.

OFFGAS SYSTEM:	800 SCFM offgas treatment capacity Submerged bed scrubbers HEMEs Packed column Hydrosonic scrubber High pressure drop venturi scrubbers Activated carbon absorption High efficiency metal fiber filter HEPA Thermosyphon evaporator, concentrator Offgas characterization equipment includes particulate size fraction characterization (0.3 to >10μm) and compositions. Volatile organics and gases with mass spectrometry.
STATUS:	Operational

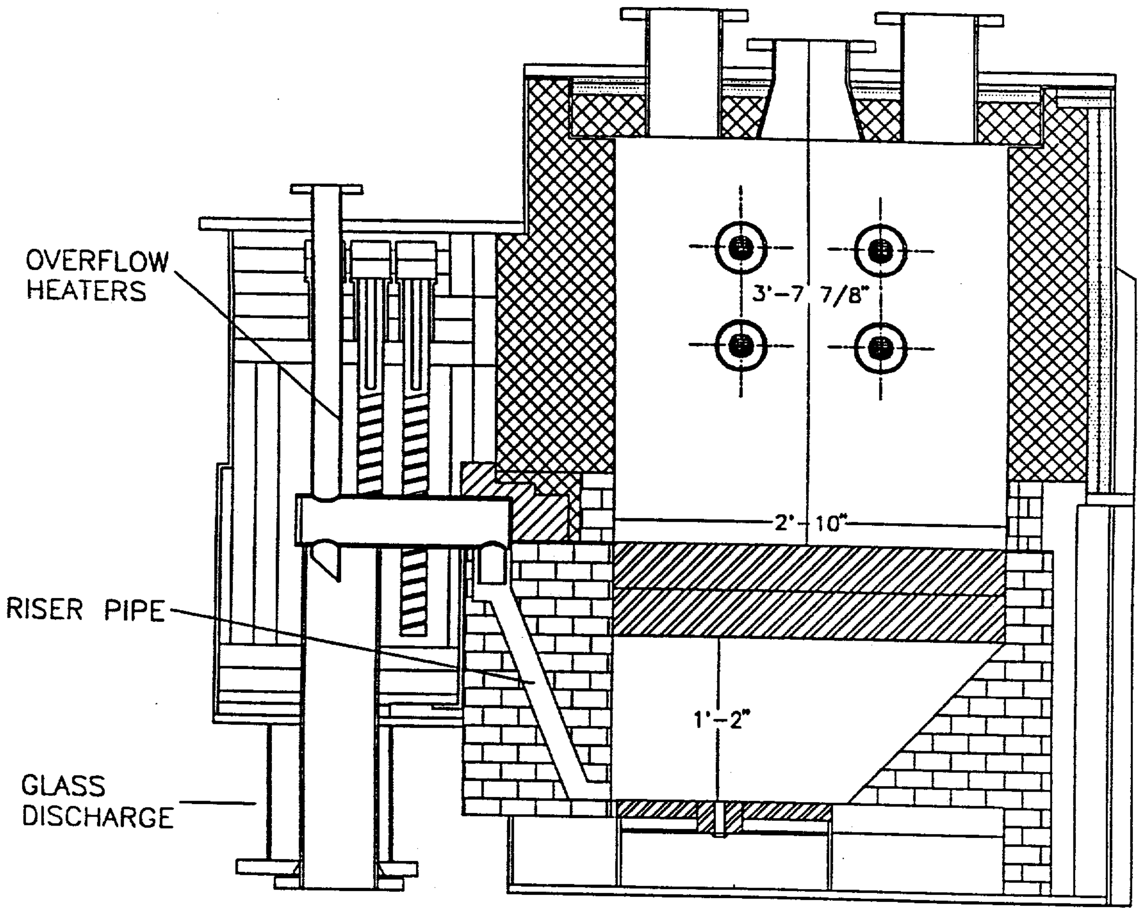

Fig. C-4. Liquid fed ceramic melter

GLASS

TITLE:	Pilot Scale Ceramic Melter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Hanford Site Richland, WA
CONTACT:	Chris Chapman: (509) 376-6576 Pacific Northwest Laboratory
CAPABILITIES:	Thermal Capacity -- ~1,800,000 BTU/hr[1] Temperature -- 1,200°C Throughput -- Inorganic solids: 1,450-1,850 kg/d; combustible: 2,200-4,500 kg/d[1]; slurries: 1,650-2,700 kg/d Treatable Waste -- Non-radioactive RCRA hazardous waste
VERSATILITY:	Waste feeding systems will handle slurries (acid, bases, neutral), sludges, and solids (soils, combustible trash, tramp metals). Device is not suitable for wastes with large metal pieces that can not be oxidized in the feed pile.
DESCRIPTION:	The Pilot Scale Ceramic Melter, shown in Figure C-5, has a rectangular melt cavity 3.4 ft long by 2.4 ft wide and 1.2 ft deep with a flat floor. It has a batch bottom drain and a conventional bottom take off, overflow discharge. The melter is enclosed in a water cooled stainless steel jacket. Electrodes are side entering plates (1 set) made of Inconel 690. The refractory lining is Monofrax K-3. Largest feed port is 12 in. wide by 18 in. long. Control and data logging equipment are associated with the system.

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[1]Existing blower limits this to about 1,200,000 BTU/hr and 1,280 kg/d of 22,000 BTU/kg feed.

OFFGAS SYSTEM:

800 SCFM offgas treatment capacity
Submerged bed scrubbers
HEMEs
Packed column
Hydrosonic scrubber
High pressure drop venturi scrubbers
Activated carbon absorption
High efficiency metal fiber filter
HEPA
Thermosyphon evaporator, concentrator

Offgas characterization equipment includes particulate size fraction characterization (0.3 to >10μm) and compositions. Volatile organics and gases with mass spectrometry.

STATUS:

Operational

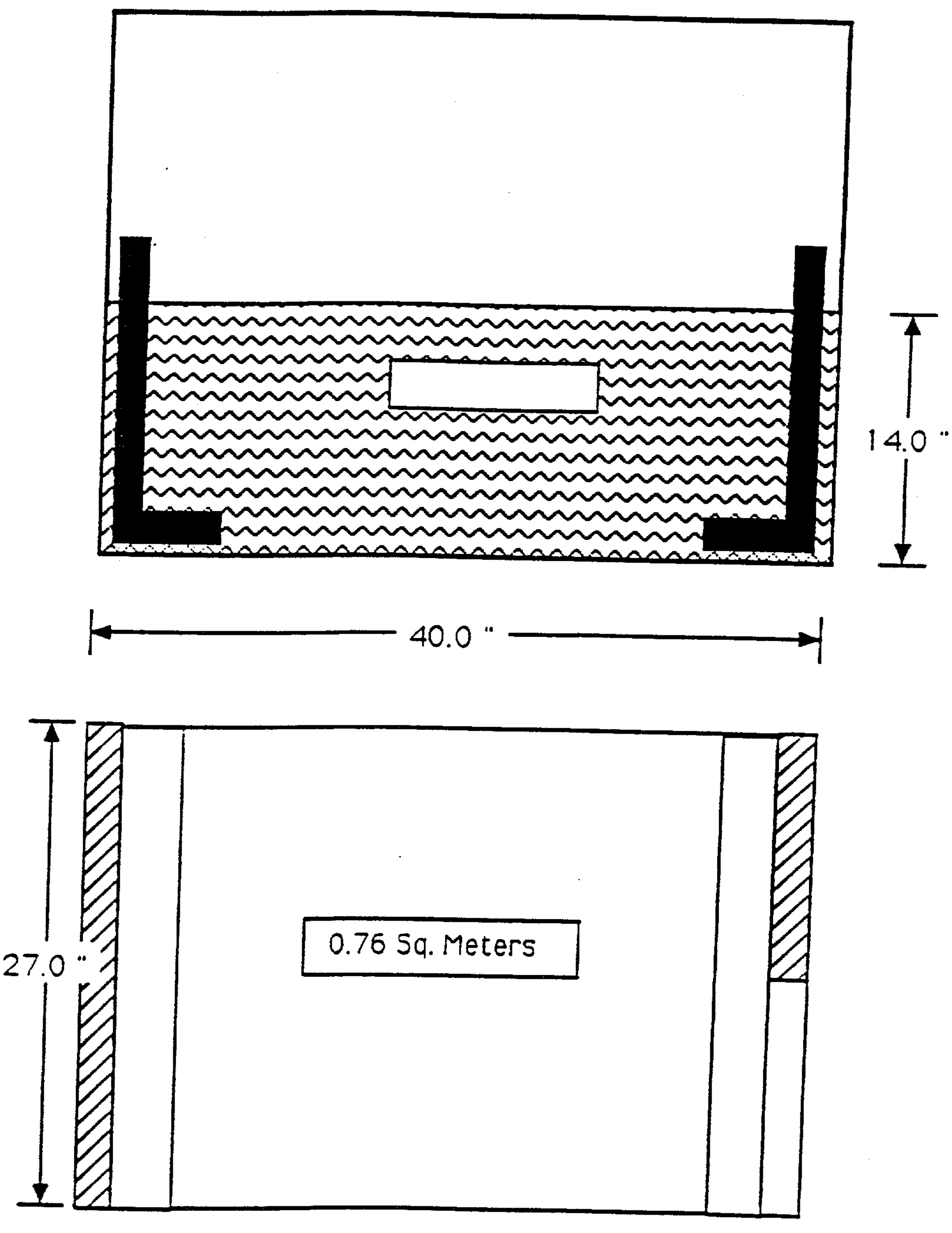

Fig. C-5. Pilot scale ceramic melter

GLASS

TITLE:	HWTF Melter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Hanford Site Richland, WA
CONTACT:	Chris Chapman: (509) 376-6576 Pacific Northwest Laboratory
CAPABILITIES:	Thermal Capacity -- ~3,400,000 Btu/hr[1] Temperature -- 1,550°C Throughput -- Inorganic solids: 1,450-1,850 kg/d; combustibles: 2,220-4,500 kg/d[1]; slurries: 1,650-2,700 kg/d Treatable Waste -- Non-radioactive RCRA hazardous wastes
VERSATILITY:	Wastes can be solutions, slurries (acid, basic or neutral), or solids (soils, combustible trash or mixtures). Device is suitable for wastes with large metal pieces.
DESCRIPTION:	The HWTF Melter, shown in Figure C-6, has a rectangular cavity 4 ft long and is 3.5 ft wide, with a glass depth of 2 ft and a sloped floor. The unit has a batch bottom drain and a conventional bottom take off, overflow discharge. Melter is enclosed in a water cooled steel jacket. Electrodes are side entering molybdenum rods (2 total). The refractory lining is Monofrax K-3 and E. Feed port is up to 24 in. wide and 24 in. long.

[1]Existing blower limits this to about 1,200,000 BTU/hr and 1,280 kg/d of 22,000 BTU/kg feed.

OFFGAS SYSTEM:	800 SCFM offgas treatment capacity Submerged bed scrubbers HEMEs Packed column Hydrosonic scrubber High pressure drop venturi scrubbers Activated carbon absorption High efficiency metal fiber filter HEPA Thermosyphon evaporator, concentrator
STATUS:	Design completed; shell fabricated.

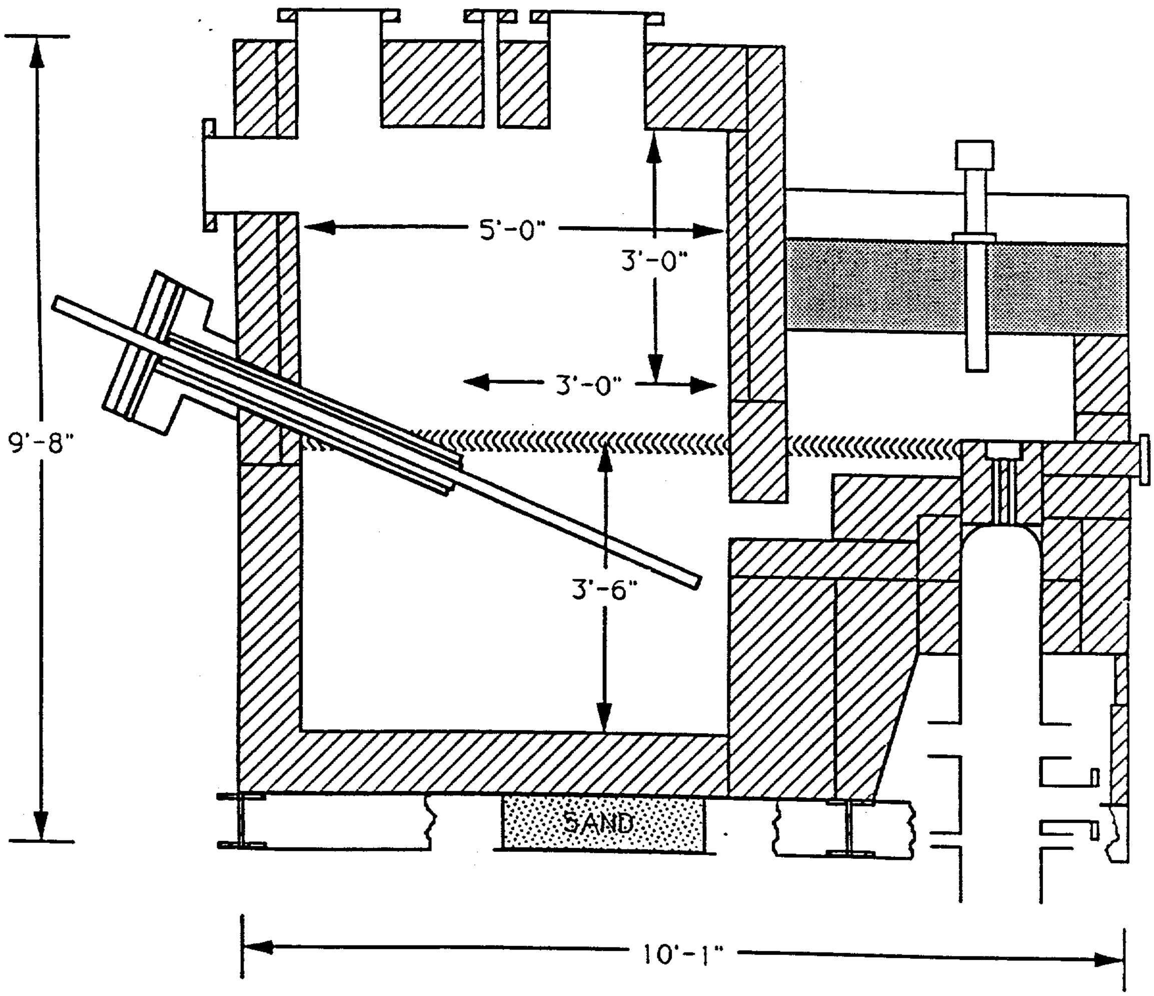

Fig. C-6. HWTF Melter

GLASS

TITLE:	Fixed Hearth Plasma Process
EQUIPMENT:	Plasma Arc Furnace
LOCATION:	Retech, Inc. Ukiah, CA
CONTACT:	Ray L. Geimer: (208) 528-2144 Science Application International Corporation
CAPABILITIES:	Thermal Capacity -- 3,000,000 BTU/hr Temperature -- 1,800°C Maximum Throughput -- 300 kg/hr Treatable Waste -- Bulk metals, soils, sludges, solid combustibles, ash, cemented sludges, solid graphite, bricks, concrete blocks. Can perform RCRA Treatability Tests.
VERSATILITY:	Wastes can be non-homogeneous mixtures of metals, inert solids, and combustibles. Wastes can be feed in whole in 30-gal drums (55-gal drums can be used with some modification to the feed system). Waste with any heating value (0-20,000 BTU/lb) can be treated by this system. Waste can include solid such as bricks, concrete, or bulk metal objects. Sludge wastes and partially (or completely) solidified sludges can be processed.
DESCRIPTION:	The primary furnace chamber has a 1.2 MW plasma torch that can be operated on He, Ar, N, O, air, or mixtures of these gases. The feed chamber is large enough to accommodate whole 30-gal drums and could be easily modified to accommodate 55-gal drums. The system operates in a batch mode and can operate for 2-4 hrs depending on feed composition. The primary furnace is a water cooled, refractory lined chamber capable of vacuum tight operation at temperatures up to 1,800°C. The secondary combustion chamber is a water cooled, refractory lined vessel capable of operating at temperatures up to 1,400°C. The secondary combustion chamber has an auxiliary natural gas burner that will deliver up to 1,000,000 BTU/hr. Combustion air is supplied to the primary and secondary chamber by a 7.5-hp blower rated at 1,000 scfm.

OFFGAS SYSTEM:	Gases exit the secondary combustion chamber and are immediately quenched by an air atomized water spray. Warm dry gases (200°C) exit the evaporative cooler and are filtered in a high temperature baghouse (51 m^2 of filter area). Flow of gas is induced by a 20-hp fan with a capacity at 5,000 scfm at 10-in. water column.
STATUS:	Operational

GLASS

TITLE:	Joule-Heated Research Melter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Savannah River Site Aiken, SC
CONTACT:	Dennis Bickford: (803) 725-3737 Westinghouse Savannah River Company
CAPABILITIES:	Thermal Capacity -- 8.4 kW Temperature -- 1,200°C Maximum Throughput -- 2 lb/hr (dry feed @ 50%) Treatable Waste -- simulated waste slurry and hazardous materials
VERSATILITY:	Installed in chemical hood to permit handling of various toxic materials. Full lid heating capacity. Normally used with mercury, silver, lead, selenium, etc. Frequently used for waste solubility, waste form quality, glass redox control measurements. Major changes in batch chemistry are tried here before tests in pilot scale melters. Tilt to pour mechanism. Third generation, 15 yrs experience, repaired and replaced as necessary.
DESCRIPTION:	The Research Melter is used for electric Joule heating of slurry which can contain hazardous materials, including mercury for melting temperatures up to 1,200°C. The enclosed melter system utilizes Inconel 690 electrodes and includes the compete offgas system. The melter produces 1-3 lb/hr output. No additional permits are required for experimental simulated waste.
OFFGAS SYSTEM:	Fully scaled down DWPF system: Venturi scrubber Steam atomized scrubber and cyclone Condenser and demister HEPA filtration Filter disk and bubble scrubbers for special offgas analysis
STATUS:	Operational

GLASS

TITLE:	High Level Caves -- Joule-Heated Research Melter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Savannah River Site Aiken, SC
CONTACT:	Dennis Bickford: (803) 725-3737 Westinghouse Savannah River Company
CAPABILITIES:	Thermal Capacity -- 8.4 kW Temperature -- 1150°C Maximum Throughput -- 2 lb/hr (dry feed @ 50%) Treatable Waste -- Radioactive waste slurry and hazardous materials
VERSATILITY:	Full lid heating capacity. Installed in high-level cell to permit handling of high-level waste and various toxic materials. Frequently used for high-level waste verification tests. Third generation, 15 years operation, rebuilt and replaced as necessary. Tilt to pour mechanism. Same facility has capability of performing leach testing, ICP-AES for elemental analysis, and radiological testing.
DESCRIPTION:	Can vitrify radioactive waste slurry in a Research Melter; very similar to the Joule-Heated Research Melter described above.
OFFGAS SYSTEM:	Venturi scrubber Condenser and demister HEPA filtration Filter disk and bubbler scrubbers for special offgas analyses
STATUS:	Operational

GLASS

TITLE:	High Temperature Melter
EQUIPMENT:	Induction Melter
LOCATION:	Savannah River Site Aiken, SC
CONTACT:	Dennis Bickford: (803) 725-3737 Savannah River
CAPABILITIES:	Thermal Capacity -- N/A Temperature -- 1,900°C Throughput -- 20 lb/hr Treatable Waste -- Low-level mixed waste
VERSATILITY:	Rapid heating to desired temperature, with maximum temperature about 2,000°C. Replaceable melt container. Has been used with depleted, natural, and enriched uranium. Tilt to pour. Especially applicable for tests where molten steel, stainless steel, iron, etc., are produced. Ideal for metal recycling and reclamation test. Temperatures are better controlled than with arc or plasma melting, minimizing volatilization of low boiling point metals such as cadmium and zinc. Can be fitted with air lance or oxygen lance for oxidation of organics. Has induction stirring for homogenization and improved metal recovery. A similar unit was used for production of plutonium alloys (design of containment facility available).
DESCRIPTION:	Used for the induction melting of electrically insulating or conductive materials, and their mixtures. Equipment is located in a lab with a 2-in. metal shear and other furnaces operating from 1,000-1,600°C. Permitted for low-level radioactive testing and hazardous materials, with a limit of 500 grams enriched uranium. Similar unit could be made transportable. Off the shelf scale up to 50 tons/day.
OFFGAS SYSTEM:	Exhauster, double HEPA filtration and stack. Licensed for use with LLMW.
STATUS:	Installed and available. Offgas upgrade scheduled for January 1993.

GLASS

TITLE: Pilot Scale Joule-Heated Melter at the TNX Area

EQUIPMENT: Joule-Heated Melter

LOCATION: Savannah River Site
Aiken, SC

CONTACT: Dennis Bickford: (803) 725-3737
Westinghouse Savannah River Company

CAPABILITIES: Thermal Capacity -- 56 kW
Temperature -- 1,150°C
Throughput -- 10 lb/hr
Treatable Waste -- Simulated waste streams and hazardous materials

VERSATILITY: A $16,000,000 fully integrated melter system duplicating DWPF process. All major feed preparation and offgas scrubbing equipment are run using instrumental controls similar to those of the DWPF. Most feed preparation and offgas system components are made of Hastelloy C-276, permitting full flowsheet amounts of corrosive acids, halides, sulfates, etc. Normally operates with Hg, Ag, Se, Cd, Pb, Cr, Cu, H_2SO_4, HNO_3, etc.

DESCRIPTION: Complete pilot-scale facilities are available for pre-processing the waste stream, Joule-heat glass melting, process control, and waste glass evaluation. Expertise includes process design and modification, process evaluation, process evaluation, process control, process modeling and offgas design. Permits include mercury and hazardous materials.

OFFGAS SYSTEM: Extensive instrumentation of offgas system and feed preparation offgas allows monitoring for CO, CO_2, H_2, NO, N_2O, SO_2,and organics.

STATUS: Operating now.

GLASS

TITLE:	High Temperature Glass Melter
EQUIPMENT:	TECO Joule Heated Melter
LOCATION:	DOE Industrial Center for Vitrification Clemson, SC
CONTACT:	Dennis Bickford: (803) 648-6317 Westinghouse Savannah River Company
CAPABILITIES:	Thermal Capacity -- 100 kW Temperature --1,600°C Maximum Throughput -- 120 lb/hr Treatable Waste -- Simulated wastes and hazardous materials
VERSATILITY:	Especially designed for rapid and inexpensive disassembly and reconfiguration (one week turn around time). Is being modified to permit recovery of molten copper alloys form circuit boards. Will be used to examine alternative electrode materials, and a range of oxidation reduction conditions.
DESCRIPTION:	The melter was especially designed for hazardous waste vitrification by one of the world's largest suppliers of commercial electric melter. It is portable and has been used at 3 different sites for pilot scale tests. The manufacturer can supply similar unity with capacities of over 10 tons/day. A high intensity electric field provides locally high temperatures, while maintaining the low pollution characteristics of a cold top melter. Necessary permits are being obtained by Clemson University to operate for Sandia National Laboratories and Savannah River Site simulated waste.
OFFGAS:	Portable and fully integrated DWPF system with Quencher/scrubber Offgas condensate tank Atomized supersonic scrubber and cyclone Condenser and mist Eliminator Reheater and HEPA Filtration Exhauster Stack (not portable) The offgas system is arranged with the necessary taps for particulate and gas emission measurements.
STATUS:	Ready to ship to Clemson November 1992.

GLASS

TITLE:	Lab Scale Stirred Glass Melter
EQUIPMENT:	Glasstech 1/4 ft^2 Stirred Melter
LOCATION:	DOE Industrial Center for Vitrification Clemson, SC
CONTACT:	Dennis Bickford: (803)648-6317 Westinghouse Savannah River Company
CAPABILITIES:	Thermal Capacity -- 15 kW Temperature -- 1,200°C Maximum Throughput -- 8 lb/hr Treatable Waste -- Simulated wastes, wastes slurries, and hazardous materials
VERSATILITY:	Highest throughput per unit size of any joule heated melter. Especially designed for low cost, rapid and inexpensive disassembly and reconfiguration (one week turn around time). Is being used to investigate direct vitrification of wastes under a range of oxidation reduction conditions, and for development of melter sensors.
DESCRIPTION:	The melter was especially designed for hazardous waste vitrification in cooperation with the Savannah River Site. The manufacturer can supply similar units with capacities of over 6 tons/day. Stirring provides exceptionally high melting rates while minimizing the temperature and surface area available for volatilization of waste components. Can be operated as a batch process to partially maintain the low pollution characteristics of a cold top melter. Necessary permits are being obtained by Clemson University to operate for Sandia National Laboratory and Savannah River Site simulated waste.
OFFGAS SYSTEM:	Normally vented to laboratory hood, can be fitted with necessary scrubbers and samplers for specific tests.
STATUS:	Ready for shipment November 1992.

GLASS

TITLE:	Production Scale Stirred Glass Melter
EQUIPMENT:	Glasstech 9 ft^2 Stirred Melter
LOCATION:	Savannah River Site Aiken, SC
CONTACT:	Technical -- Dennis Bickford: (803) 648-6317 Westinghouse Savannah River Company Commercial -- Ray Richards (419) 536-8828 Kenneth Wetmore (419) 661-9500 Stir-Melter, Inc.
CAPABILITIES:	Thermal Capacity -- 600 kW Temperature -- 1,200°C Maximum Throughput -- 228 lb/hr slurry; 500 lb/hr dry feed Treatable Waste -- Simulated wastes, wastes slurries, and hazardous materials
VERSATILITY:	Highest throughput per unit size of any joule heated melter. Especially designed for low cost, rapid and inexpensive disassembly and reconfiguration (one month turn around time). Is being used to investigate less expensive and more easily repaired melters for high level waste. Is available part time for non-HLW programs. Will be used for direct vitrification of wastes under a range of oxidation reduction conditions, and for development of melter sensors.
DESCRIPTION:	The melter was especially designed for hazardous waste vitrification in cooperation with Savannah River Site. The manufacturer can supply similar units with capacities of over 6 tons/day. Stirring provides exceptionally high melting rates while minimizing the temperature and surface area available for volatilization of waste components. Can be operated batch-wise to partially maintain the low pollution characteristics of a cold top melter. Necessary permits are in place to operate for Savannah River Site waste simulants, including actual hazardous components.

OFFGAS SYSTEM: A \$16,000,000 fully integrated melter system duplicating DWPF process. All major feed preparation and offgas scrubbing equipment is run using similar instrumental controls as the DWPF. Most feed preparation and offgas system components are made of Hastelloy C-276, permitting full flowsheet amounts of corrosive acids, halides, sulfates, etc. Extensive instrumentation of offgas system and feed preparation offgas allows monitoring for CO, CO_2, H_2, NO, NO_2, N_2O, SO_2, and organics. Normally operates with Hg, Ag, Se, Cd, Pb, Cr, Cu, H_2SO_4, HNO_3, etc.

STATUS: Finalizing purchasing contract.

GLASS

TITLE:	Lab Scale Rotary Calciner/Melter
EQUIPMENT:	Custom Laboratory Rotary Calciner/Melter
LOCATION:	Savannah River Site Aiken, SC
CONTACT:	Dennis Bickford: (803) 648-6317 Westinghouse Savannah River Company
CAPABILITIES:	Thermal Capacity -- 3 kW Temperature -- 1,300°C Maximum Throughput -- 0.5 lb/hr Treatable Waste -- LLMW, waste slurries, and hazardous materials
VERSATILITY:	Very small unit for chemical characterization of waste and offgas. Especially designed for low cost operation and inexpensive disassembly and reconfiguration. It is being used to calcine wastes prior to vitrification in crucibles, and for offgas sampling.
DESCRIPTION:	The melter was especially designed for hazardous waste oxidation and vitrification by Savannah River Site.
OFFGAS SYSTEM:	It is normally fitted with condenser and vented to hood. Can be fitted with glass pouring, offgas sampling as required.
STATUS:	Built and ready for installation.

GLASS

TITLE: WV-0.25 Stir-Melter, Inc.

EQUIPMENT: Joule-Heated Melter

LOCATION: Stir-Melter, Inc.
Perrysburg, OH

CONTACT: Technical: Ray Richards -- (419) 536-8828
Commercial: Kenneth Wetmore -- (419) 661-9500

CAPABILITIES: Thermal Capacity -- 10 kW
Temperature -- 1,050°C
Maximum Throughput[1] -- 120 kg/d (glass output from dry feed); 80 kg/d (glass output from 60% slurry)
Treatable Waste -- RCRA hazardous waste

VERSATILITY: Stir-Melters are highly driven refractory or metal lined Joule-heated glass melters. They are much smaller in size than most other melters; quickly started and stopped, and offgases can be limited to those emanating from the feed materials. Feed materials tested include 60% water slurries, dry feed including modest amounts of organics, and light materials such as fiberglass scrap. The operating temperature limits for the metal lined melters in 1,050°C. A second stage non-stirred superheater operating at 1,150°C can be provided. The refractory lined units can operate at over 1,600°C.

DESCRIPTION: This is a 0.25 ft^2 area melter, designed specifically for simulated radioactive and hazardous wastes. It is an all metal, partially sealed unit with an upper temperature limit of 1,050°C.

OFFGAS SYSTEM: The size of this unit lends itself easily to glove-box enclosure for offgas containment. Stir-Melter, Inc. can perform melting trials. Stack sampling and testing can be obtained locally. Other testing and characterization is provided by other vendors.

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[1]Lab EPA permit limits 250 kg of waste per day and a total limit of 1000 kg for any one waste stream. Radioactive materials cannot be accepted.

STATUS: The piece of equipment will be available in the fall of 1992 for demonstration through Stir-Melter, Inc. in its laboratory facility.

GLASS

TITLE: WV-1 Stir Melter

EQUIPMENT: Joule-Heated Melter

LOCATION: Stir Melter, Inc.
Perrysburg, OH

CONTACT: Technical -- Ray Richards: (419) 536-8828
Commercial -- Kenneth Wetmore: (419) 661-9500

CAPABILITIES: Thermal Capacity -- 60 kW
Temperature -- 1,050°C
Maximum Throughput[1] -- 500 kg/d (glass output from dry feed); 350 kg/d (glass output from 60% slurry)
Treatable Waste -- RCRA hazardous waste

VERSATILITY: Stir-Melters are highly driven refractory or metal lined Joule-heated glass melters. They are much smaller in size than most other melters; quickly started and stopped, and offgases can be limited to those emanating from the feed materials. Feed materials tested include 60% water slurries, dry feed including modest amounts of organics, and light materials such as fiberglass scrap. The operating temperature limits for the metal lined melters in 1,050°C. A second stage non-stirred superheater operating at 1,150°C can be provided. The refractory lined units can operate at over 1,600°C.

DESCRIPTION: This is a 1 ft^2 area melter, designed specifically for simulated radioactive and hazardous wastes. It is an all metal, sealed unit with an upper temperature limit of 1,050°C.It has been tested for over 3,700 hrs. Much of this time was spent on simulated high-level waste from the Savannah River Site. This was a 60 weight % water/solids slurry and the melter produced over 14.5 kg/hr of glass output. A dry feed of similar composition was also tested and produced a melting rate of over 21.4 kg/hr.

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[1]Lab EPA permit limits 250 kg of waste per day and a total limit of 1000 kg for any one waste stream. Radioactive materials cannot be accepted.

OFFGAS SYSTEM: Stir-Melter, Inc. units are equipped with an offgas port which is typically connected to offgas handling equipment specifically designed for each application and supplied by the client or other vendors. Stir-Melter, Inc. can perform melting trials. Stack

sampling and testing can be obtained locally. Other testing and characterization is provided by other vendors.

STATUS: This piece of equipment is available for demonstration through Stir-Melter, Inc. in its laboratory facility.

GLASS

TITLE:	MiniMelter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Vitreous State Laboratory of Catholic University of America Washington, DC
CONTACT:	Pedro B. Macedo: (202) 319-5329 Vitreous State Laboratory
CAPABILITIES:	Thermal Capacity -- 8 kW Temperature -- 1,150°C Throughput -- 10 kg/d to 30 kg/d Treatable Waste -- RCRA hazardous and low-level radioactive waste
VERSATILITY:	Waste feeds can be dry, semi-dry, slurry, or liquid.
DESCRIPTION:	MiniMelter is the smallest vitrification furnace with nominal capacity of 10 kg/day. This is an electrically heated furnace allowing small scale studies on various feed materials. The MiniMelter operates at temperatures not higher than 1,200°C. It is equipped with a system for continuous feeding of dry and semi-dry materials as well as wet sludges. It possesses an off-gas system for full capture of evaporation products. The MiniMelter operates in the batch mode. For some typical waste processed at Vitreous State Laboratory, this furnace could process up to 30 kg/day.
OFFGAS SYSTEM:	Oil bucket particulate collector HEPA filtration system
STATUS:	--

GLASS

TITLE:	MicroMelter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Vitreous State Laboratory of Catholic University of America Washington, DC
CONTACT:	Pedro B. Macedo: (202) 319-5329 Vitreous State Laboratory
CAPABILITIES:	Thermal Capacity -- 12 kW Temperature -- 1,150°C Throughput -- 30 kg/d to 100 kg/d Treatable Waste -- RCRA hazardous and low-level radioactive waste
VERSATILITY:	Waste feeds can be dry, semi-dry, slurry, or liquid.
DESCRIPTION:	MicroMelter is a larger unit with all characteristics of a pilot-plant installation. Its nominal capacity is 30 kg/day and it allows quick, inexpensive vitrification studies on all kinds of feed materials at temperatures not higher than 1,200°C. The MicroMelter is also an electrically-heated furnace. It is equipped with a proprietary mixing system which ensures rapid and uniform mixing of waste materials and glass formers. The MicroMelter can safely handle low-level radioactive wastes. It operates in the continuous mode and possesses a relatively sophisticated offgas system. For some typical wastes processed at Vitreous State Laboratory, this furnace could process up to 100 kg/day of waste.
OFFGAS SYSTEM:	Quencher Scrubber Bag filter HEPA filtration system
STATUS:	--

GLASS

TITLE:	100 kg/day Melter
EQUIPMENT:	Joule-Heated Melter
LOCATION:	Vitreous State Laboratory of Catholic University of America Washington, DC
CONTACT:	Pedro B. Macedo: (202) 319-5329 Vitreous State Laboratory
CAPABILITIES:	Thermal Capacity -- 42 kW Temperature -- 1,150°C Throughput -- 100 kg/day to 900 kg/day Treatable Waste -- RCRA hazardous and low-level ladioactive waste
VERSATILITY:	Waste feeds can be dry, semi-dry, slurry, or liquid.
DESCRIPTION:	When operational, the 100 kg/day Melter will posses all of the advanced features of the MiniMelter, but will allow vitrification studies at a larger scale. It will be capable of handling low-level radioactive wastes. For some typical wastes processed at the Vitreous State Laboratory, this furnace is capable of processing up to 900 kg/day of waste.
OFFGAS SYSTEM:	The offgas system consists of a quencher, packed bed scrubber, mist eliminator, bag filter, and HEPA filtration unit. Both liquid and gaseous waste streams are fully recyclable.
STATUS:	100 kg/day Melter is currently in the construction stage and will become operational at the beginning of October 1992.

GLASS

TITLE: 1,000 kg/day Melter

EQUIPMENT: Joule-Heated Melter

LOCATION: Vitreous State Laboratory of Catholic University of America
Washington, DC

CONTACT: Pedro B. Macedo: (202) 319-5329
Vitreous State Laboratory

CAPABILITIES: Thermal Capacity -- 125 kW
Temperature -- 1,150°C
Throughput -- 1,000 kg/day to 5,000 kg/day
Treatable Waste -- Asbestos-contaminated and simulated radioactive wastes

VERSATILITY: Waste feeds can be dry, semi-dry, slurry, or liquid.

DESCRIPTION: The 1,000 kg/day Melter will provide yet another intermediate step in the cost-effective scale-up studies which will lead to the construction and utilization of the full-scale vitrification plants. The 1,000 kg/d unit will be able to process asbestos-containing waste streams and simulated radioactive wastes.

It is expected that for the typical wastes processed at Vitreous State Laboratory that the furnace would be capable of processing up to 5,000 kg/day of waste.

OFFGAS SYSTEM: The offgas system consists of the following major components connected in series: film cooler, quencher, packed bed spray tower, horizontal mist eliminator, reheater, bag filter, and HEPA unit. Both gaseous and liquid wastes streams are generated. The gaseous stream is either recycled or disposed of directly or after ion exchange depending on composition. The offgas is constantly monitored on the operational, safety and environmental levels. Sensors are wired through the A&B PLC controller with safety level being interlocked to the system feed.

STATUS: 1,000 kg/day Melter is in the final stage of design and will become operational in the late fall of 1992.

HYDRAULIC CEMENT

TITLE:	Ashcrete Process
EQUIPMENT:	End-over-end drum tumbler from Stock Equipment Company
LOCATION:	Savannah River Laboratory
CONTACT:	Don Fisher (803/725-6428)
CAPABILITIES:	The Ashcrete Process solidifies ash generated by the Beta Gamma Incinerator at Savannah River Plant and produces a cement waste form acceptable for burial. It processes ash within the same drum received from the incinerator.
VERSATILITY:	The in-container mixing system used makes the equipment versatile and amenable to also solidify liquid and slurry wastes with minor modifications.
DESCRIPTION:	At Station 1, the ash-filled drum is weighed and two iron mixing bars are placed inside it. The requisite water addition is made at Station 2 and cement and sand are added at Station 3. The cap is replaced at Station 4 and the end-over-end tumbler mechanism at Station 5 clamps the drum and rotates it at 18 rpm. This mixes the ashcrete without any physical contact between the process equipment and the contaminated ash.
OFFGAS SYSTEM:	Other than the routine air-balance control, there is no offgas system required.
STATUS:	Operational

HYDRAULIC CEMENT

TITLE:	Transportable Grout Equipment Facility
EQUIPMENT:	Twin-screw variable speed in-line mixer and progressive cavity grout pump
LOCATION:	Hanford Site
CONTACT:	J. A. Voogd (509) 373-5642
CAPABILITIES:	Provides for the remotely-operated mixing of selected liquid wastes with the dry grout solids and delivery at 30-70 GPM of the resulting slurry to the disposal vaults where solidification occurs.
VERSATILITY:	Like most cement systems, this Grout Facility can adjust its dry grout-forming solids ratios to match the needs of changing input waste streams. All process control is performed by a programmable logic controller. There is an optimum balance of automatic control and operator initiated control. The operator interface with the control system consists of a set of keyboards and CRT monitors. The CRTs provide menus to assist the operator in performing the control actions and in selecting different screens for monitoring different portions of the process.
DESCRIPTION:	The grout facility was constructed in eight modules which provide for the remote waste mixing and pumping and all necessary process support and control. Inside the Mixer Module the dry blend material is mixed with the radioactive waste stream in a twin-screw variable speed in-line mixer. Liquid process additives are metered into the waste stream just prior to its entry into the mixer. The mixed grout slurry is deposited in a surge tank which provides a constant supply of material for the grout pump.
OFFGAS SYSTEM:	The exhaust system draws air at 850 scfm from the Mixer Module and the baghouse dust collection system which ventilates the grout surge tank. After passing through dual HEPA filtration trains, the filtered air is sent to a stack for monitoring and release.
STATUS:	Operational

SULFUR POLYMER CEMENT

TITLE:	Modified Sulfur Cement Encapsulation Process
EQUIPMENT:	Modified Sulfur Cement Process Equipment
LOCATION:	Brookhaven National Laboratory Upton, NY
CONTACT:	Paul Kalb: (516) 282-7644 Brookhaven National Laboratory
CAPABILITIES:	Thermal Capacity -- N/A Temperature -- 120 to 130°C Maximum Throughput -- 1 to 2 kg/hr for bench-scale process Treatable Waste -- RCRA hazardous and low-level radioactive waste
VERSATILITY:	Treat a wide variety of waste streams including salts and other aqueous wastes, sludges, incinerator ash, evaporator concentrates, dry solids, and ion exchange resins. Can be easily scaled to pilot or production scale.
DESCRIPTION:	Bench-scale processing equipment for the modified sulfur cement encapsulation process include a double planetary orbital mixer with jacketed heating/mixing vessel, vacuum hood, oil bath circulation heater, and hydraulic platen discharge unit.
OFFGAS SYSTEM:	A HEPA filter enclosure has been constructed to enhance capabilities to process radioactive and hazardous materials.
STATUS:	Bench-scale process operational.

CERAMIC

TITLE:	Ceramic Fabrication Equipment
EQUIPMENT:	
LOCATION:	Lawrence Livermore National Laboratory Livermore, CA
CONTACT:	Virginia Oversby: Lawrence Livermore National Laboratory
CAPABILITIES:	Thermal Capacity -- N/A Temperature -- N/A Nominal Throughput -- N/A Treatable Waste -- RCRA Hazardous and Radioactive Waste
VERSATILITY:	N/A
DESCRIPTION:	The equipment available at Lawrence Livermore National Laboratory for waste form production and testing includes controlled atmosphere glove boxes for handling radioactive and hazardous materials, high temperature furnaces for sintering operations, presses of various sizes and pressure capabilities for both hot and cold pressing, and the full range of chemical analysis capabilities required to support EPA test protocols.
OFFGAS SYSTEM:	N/A
STATUS:	Operational

ORGANIC BINDER

TITLE:	Polyethylene Encapsulation Process Equipment
EQUIPMENT:	Polyethylene Screw Extruder
LOCATION:	Brookhaven National Laboratory Upton, NY
CONTACT:	Paul Kalb: (516) 282-7644 Brookhaven National Laboratory
CAPABILITIES:	Thermal Capacity -- N/A Temperature -- N/A Maximum Throughput -- N/A Treatable Waste -- RCRA hazardous and low-level radioactive waste
VERSATILITY:	Treat a wide variety of waste streams including salts and other aqueous wastes, sludges, incinerator ash, evaporator concentrates, dry solids, and ion exchange resins.
DESCRIPTION:	Polyethylene encapsulation process equipment include two bench-scale single screw extruders, several volumetric feeders for precise metering of waste and binder, waste form specimen molds and miscellaneous pre-treatment equipment. A production-scale extruder has been procured and will be sinstalled at BNL for the purpose of scale-up studies and full-scale process demonstration.
OFFGAS SYSTEM:	A HEPA filter enclosure has been constructed to enhance capabilities to process radioactive and hazardous materials.
STATUS:	Bench-scale operational. A full scale test facility is planned for FY-93.

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APPENDIX D
SUMMARIES FOR FINAL WASTE FORMS

GLASS SUMMARIES

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GLASS SUMMARIES INDEX

NO. 1	AUTHOR:	
	TITLE:	Summary of Properties of Borosilicate Waste Glasses
	PUBLICATION:	
	DATE:	
NO. 2	AUTHOR:	
	TITLE:	A State-of-the-Art Review of Materials Properties of Nuclear Waste Forms
	PUBLICATION:	USDOE, PNL-3802 UC-70
	DATE:	4/1/81
NO. 3	AUTHOR:	
	TITLE:	Vitrification Technologies for Treatment of Hazardous and Radioactive Waste
	PUBLICATION:	EPA/625/R-92/002 U.S. EPA, Center for Environmental Research Information, Cincinnati, OH 45268
	DATE:	
NO. 4	AUTHOR:	Andrews, M.K.; Bibler, N.E.; Jantzen, C.M.; Beam, D.C.
	TITLE:	Initial Demonstration of the DWPF Vitrification Process and Product Control Strategy Using Actual Radioactive Waste
	PUBLICATION:	Ceramic Transactions, Nuclear Waste Management IV, Vol 23, p. 569-576
	DATE:	4/29/91
NO. 5	AUTHOR:	Bates, S.O.; Bowen, W.M.
	TITLE:	Interim Milestone HWVP-86-V1122C-Report on Composition Variability Testing Conducted for the HWVP
	PUBLICATION:	HWVP-86-V1122C Final Report
	DATE:	3/1/87
NO. 6	AUTHOR:	Bates, J.K.; Jardine, L.J.; Steindler, M.J.
	TITLE:	The Hydration Process of Nuclear Waste Glass: An Interim Report
	PUBLICATION:	Argonne National Lab Report ANL 82-11
	DATE:	1/1/82

NO. 7	AUTHOR:	Bates, J.K.; Jardine, L.J.; Flynn, K.F.; Steindler, M.J.
	TITLE:	The Application of Neutron Activation Analysis to the Determination of Leach Rates of Simulated Nuclear Waste Forms
	PUBLICATION:	Argonne National Lab Report
	DATE:	1/1/81
NO. 8	AUTHOR:	Bergsman, T.M.; Shade, J.W.; Farnsworth, R.K.
	TITLE:	Fifth In Situ Vitrification Engineering-Scale Test of Simulated INEL Buried Waste Sites
	PUBLICATION:	Battelle, PNL-8152, Prepared for USDOE,
	DATE:	June 1992
NO. 9	AUTHOR:	Bibler, N.E.; Jantzen, C.M.
	TITLE:	The Product Consistency Test and its Role in the Waste Glass Acceptance Process for DWPF Glass
	PUBLICATION:	Waste Management '89, Vol. 2, R.G. Post Ed. p 743-749
	DATE:	1/1/89
NO. 10	AUTHOR:	Bibler, N.E.; Jantzen, C.M.
	TITLE:	Materials Interactions Relating to Long-Term Geologic Disposal of Nuclear Waste Glass
	PUBLICATION:	Scientific Basis for Nuclear Waste Management, X J.K. Bates (Ed), P. 47-66, Materials Research Society, Pittsburg
	DATE:	1/1/89
NO. 11	AUTHOR:	Bickford, D.F.; Smith, M.E.; Allen, P.M.; Faraci, J.P.; Langton, C.A.; Wolf, K.Z.
	TITLE:	Application of High Level Waste-Glass Technology to the Volume Reduction and Immobilization of TRU, Low Level, and Mixed Wastes
	PUBLICATION:	Proceedings "Waste Management '91" RG Post Ed. ANS Tucson, AZ p. 537-545
	DATE:	1/1/91
NO. 12	AUTHOR:	Bickford, D.F.; Ramsey, A.A.; Jantzen, C.M.; Brown, K.G.
	TITLE:	Control of Radioactive Waste Glass Melters: I, Preliminary General Limits at Savannah River
	PUBLICATION:	Journal of American Ceramic Society, Vol. 73, 10, p. 2896-2902
	DATE:	10/1/90

NO. 13
AUTHOR: Bickford, D.F.; Hrma, P.; Bowan, B.W.
TITLE: Control of Radioactive Waste Glass Melters: II, Residence Time and Melt Rate Limitations
PUBLICATION: Journal American Ceramic Society, Vol. 73, 10 p. 2903-2915
DATE: 10/1/90

NO. 14
AUTHOR: Bickford, D. F.
TITLE: Advanced Radioactive Waste-Glass Melters
PUBLICATION: Presentation to American Ceramic Society, Tutorial Lecture on Novel Ceramic Processing/Nuclear Division, WSRC-RP-89-1174
DATE: 4/22/90

NO. 15
AUTHOR: Bickford, D.F.; Probst, R.C.; Plodinec, M.J.
TITLE: Control of Radioactive Waste-Glass Melters: Part 3 - Glass Electrical Stability
PUBLICATION: Advances in the Fusion of Glass, D.F. Bickford, ed., American Ceramic Society Westerville, OH, June 1988
DATE: 6/1/88

NO. 16
AUTHOR: Bickford, D.F., Pellarin, D.J.
TITLE: Large Scale Leach Testing of DWPF Canister Sections
PUBLICATION: Savannah River Laboratory, DP-MS-86-72
DATE: 12/1/86

NO. 17
AUTHOR: Cantale, C.; Castelli, S.; Donato A.; Traverso, D.M.; Colombo, P.; Scarinci, G.
TITLE: A Borosilicate Glass for the Italian High-Level Waste - Characterization and Behavior
PUBLICATION: Radioactive Waste Management and the Nuclear Fuel Cycle, 16 (1), pp. 25-47
DATE: 1/1/91

NO. 18
AUTHOR: Chandler, G.T.; Wicks, G.G.; Wallace, R.M.
TITLE: Chemical Durability of SRP Waste Glass - Saturation Effects and Influence of SA/V
PUBLICATION: Savannah River Laboratory, DP-MS-84-37
DATE: 4/29/84

NO. 19
AUTHOR: Chapman, C.C.
TITLE: State-of-the-Art of Waste Glass Melters
PUBLICATION: 3rd International Symposium, Advances in Fusion and Processing of Glass 1992, New Orleans
DATE: 1992

NO. 20	AUTHOR:	Chapman, C.C.
	TITLE:	Evaluation of Vitrifying Municipal Incinerator Ash
	PUBLICATION:	Ceramic Transactions, Nuclear Waste Management IV, G.G. Wicks, Ed., p. 223-231
	DATE:	4/22/91
NO. 21	AUTHOR:	Chapman, C.C.; Pope, J.M.; Barnes, S.M.
	TITLE:	Electric Melting of Nuclear Waste Glasses, State of the Art
	PUBLICATION:	Journal Non-Crystalline Solids, No. 84, p. 226-240
	DATE:	1/1/86
NO. 22	AUTHOR:	Coordinated Research Programme of the Evaluation of Solidified High-Level Waste Form
	TITLE:	Chemical Durability and Related Properties of Solidified High-Level Waste Forms
	PUBLICATION:	IAEA Technical Report Series No. 257
	DATE:	1/1/85
NO. 23	AUTHOR:	Covington, J.F.; Wicks, G.G.; Molecke, M.A.
	TITLE:	WIPP/SRL In-Situ Tests: MIIT Program - The Effects of Metal Package Components
	PUBLICATION:	Ceramic Transactions, Nuclear Waste Management, Vol. 23, pp. 723-732
	DATE:	4/29/91
NO. 24	AUTHOR:	Curti, E.
	TITLE:	Modeling the Dissolution of Borosilicate Glasses for Radioactive Waste Disposal with the PHREEQE/GLASSOL Code: Theory and Practice
	PUBLICATION:	PSI-Bericht Nr. 86
	DATE:	1/1/91
NO. 25	AUTHOR:	Czuczwa, J.M.; Farzan, H.; Vecci, S.J.; Warchol, J.J.
	TITLE:	Cyclone Furnace for Vitrification of Contaminated Soil and Wastes
	PUBLICATION:	1991 Incineration Conference Proceedings, pp. 613-620, Knoxville, TN
	DATE:	May 1991

NO. 26	AUTHOR:	Delege, F.; Dussossoy, J.L.
	TITLE:	R7T7 Glass Initial Dissolution Rate Measurements Using a High-Temperature Soxhlet Device
	PUBLICATION:	Material Resource Society Symposium Proceedings 212, pp. 41-47
	DATE:	1/1/91
NO. 27	AUTHOR:	Ewing, R.C.; Jercinovic, J.J.
	TITLE:	Natural Analogues: Their Application to the Prediction of the Long-Term Behavior of Nuclear Waste Forms
	PUBLICATION:	Material Research Society Symposium Proceedings, 84, pp. 67-93
	DATE:	1/1/87
NO. 28	AUTHOR:	Gafney, J.
	TITLE:	Chemistry
	PUBLICATION:	Science News, p. 173
	DATE:	3/14/92
NO. 29	AUTHOR:	Grambow, B.; Lutze, W; Ewing, R.C.; Werme, L.O.
	TITLE:	Performance Assessment of Glass as a Long-Term Barrier to the Release of Radionuclides into the Environment
	PUBLICATION:	Material Research Society Symposium Proceedings, 112
	DATE:	1/1/88
NO. 30	AUTHOR:	Harbour, J.R.
	TITLE:	Demonstrating Compliance with the Waste Acceptance Preliminary Specifications on Foreign Materials within DWPF Canistered Waste Forms
	PUBLICATION:	Proceedings of the 2nd International Seminar, Radioactive Waste Products, E. Warnecke, et al., ed., KFA Research Julich, FRG, WSRC-MS-90-98, 1990.
	DATE:	5/28/90
NO. 31	AUTHOR:	Harbour, J.R.; Miller, T.J.; Whitaker, M.J.
	TITLE:	The Determination of Pressure, Dewpoint, and Composition of the Gas Within the Free Volume of Canistered Waste Forms
	PUBLICATION:	WSRC-RP-90-1167
	DATE:	1/1/90

NO. 32	AUTHOR:	Hazelton, R.F.; Thornhill, C.K.; Ross, W.A.
	TITLE:	Evaluation of the Potential for Gas Pressurization and Free Liquid Accumulation in a Canister from the West Valley Demonstration Project
	PUBLICATION:	Ceramic Transactions, Nuclear Waste Management, IV, Vol. 23, pp. 491-500
	DATE:	4/29/91
NO. 33	AUTHOR:	Janke, D.S.; Chapman, C.C.; Vogel, R.A.
	TITLE:	Results of Vitrifying Fernald K-65 Residue
	PUBLICATION:	Ceramic Transactions, Nuclear Waste Management, Vol. 23, pp. 53-61
	DATE:	4/29/91
NO. 34	AUTHOR:	Jantzen, C.M.
	TITLE:	Solidification of Consolidated Incinerator Facility (CIF) Wastes in Soda-Lime-Silica (SLS) Glass: Use of Reactive Additives to Retain Hazardous and Heavy Metal
	PUBLICATION:	Savannah River Lab, WSRC-TR-92-214, Rev. 0
	DATE:	4/30/92
NO. 35	AUTHOR:	Jantzen, C.M.
	TITLE:	Thermodynamic Approach to Glass Corrosion
	PUBLICATION:	Corrosion of Glass, Ceramics, and Ceramic Superconductors, Principles, Testing, Characterization and Applications, D.E. Clark and B.K. Zoitos, eds., pp. 153-215, Noves Publications, Park Ridge, NJ
	DATE:	1/1/92
NO. 36	AUTHOR:	Jantzen, C.M.
	TITLE:	First Principles Process-Product Models for Vitrification of Nuclear Waste: Relationship of Glass Composition to Glass Viscosity, Resistivity, Liquidus Temperature
	PUBLICATION:	Ceramic Transactions, Vol. 23, pp. 37-51, Nuclear Waste Management IV, G.G. Wicks, et al., eds.
	DATE:	4/29/91
NO. 37	AUTHOR:	Jantzen, C.M.
	TITLE:	Systems Approach to Nuclear Waste Glass Development
	PUBLICATION:	Journal of Non-Crystalline Solids, 84, No. 1-3, pp. 215-225
	DATE:	1/1/86

NO. 38	AUTHOR:	Jantzen, C.M.; Bibler, N.E.
	TITLE:	Nuclear Waste Glass Product Consistency Test (PCT)
	PUBLICATION:	Savannah River Site
	DATE:	1/1/90
NO. 39	AUTHOR:	Jantzen, C.M.; Bibler, N.E.
	TITLE:	The Product Consistency Test for the DWPF Wasteform
	PUBLICATION:	Proceedings of the 2nd International Seminar on Radioactive Waste Products, E. Odoj, et al., eds., pp. 609-622
	DATE:	6/1/90
NO. 40	AUTHOR:	Jantzen, C.M.; Clarke, D.R.; Morgan, P.E.D.; Harker, A.B.
	TITLE:	Leaching of Polyphase Nuclear Waste Ceramics: Microstructural and Phase Characterization
	PUBLICATION:	Journal American Ceramic Society, Vol. 76, No.6, pp. 292-300
	DATE:	6/1/82
NO. 41	AUTHOR:	Jantzen, C.M.; Plodinec, M.J.
	TITLE:	Thermodynamic Model of Natural, Medieval and Nuclear Waste Glass Durability
	PUBLICATION:	Journal of Non-Crystalline Solids, 67, pp. 107-223
	DATE:	1/1/84
NO. 42	AUTHOR:	Jercinovic, M.J.; Kaser, S.A.; Ewing, R.C.; Lutze, W.
	TITLE:	Comparison of Surface Layers Formed on Synthetic Basaltic Glass, French R7T7 and HMI Borosilicate Nuclear Waste Form Glasses-Materials Interface Interactions Tests
	PUBLICATION:	Material Research Society Symposium Proceedings, 176, pp.355-362, 1990
	DATE:	1/1/90
NO. 43	AUTHOR:	Jercinovic, M. J.; Ewing, R.C.
	TITLE:	Basaltic Glasses From Iceland and the Deep Sea: Natural Analogues to Borosilicate Nuclear Waste-Form Glass
	PUBLICATION:	JSS 88-01
	DATE:	1/1/88
NO. 44	AUTHOR:	Lutze, W.
	TITLE:	Silicate Glasses
	PUBLICATION:	Radioactive Waste Forms for the Future, W. Lutze and R.C. Ewing, Elsevier Science Publishers, B.V.
	DATE:	1/1/88

NO. 45	AUTHOR:	Lutze, W.; Ewing, R.C.
	TITLE:	Radioactive Waste Forms for the Future
	PUBLICATION:	Book, Elsevier Science Publishers, B.V., pp.699-739
	DATE:	1/1/88
NO. 46	AUTHOR:	Lutze, W.; Grambow, B.
	TITLE:	Chemical Corrosion of Lead-Iron Phosphate Glass
	PUBLICATION:	In-process
	DATE:	
NO. 47	AUTHOR:	Marples, J.A.C.; Lutze, W.; Kawanishi, M; Van Iseghem, P.
	TITLE:	A Comparison of the Behavior of Vitrified HLW in Repositories in Salt, Clay, and Granite, I: Experimental
	PUBLICATION:	Material Research Society Symposium Proceedings, 176, pp. 267-274
	DATE:	1/1/90
NO. 48	AUTHOR:	McDonell, W. R.
	TITLE:	Comparison of SRP High-Level Waste Disposal Costs for Borosilicate Glass and Crystalline Ceramic Waste Forms
	PUBLICATION:	DuPont, Savannah River Laboratory, DPST-82-346
	DATE:	4/1/82
NO. 49	AUTHOR:	Mertens, L.A.; Lutze, W.; Marples, J.A.C.; Van Iseghem, P.; Vernaz, E.
	TITLE:	A Comparison of the Behavior of Vitrified HLW In Repositories In Salt, Clay, and Granite, I: Experimental
	PUBLICATION:	Material Research Society Symposium Proceedings, 176, pp. 267-274
	DATE:	1/1/90
NO. 50	AUTHOR:	Namboodri, C.G.; Wicks, G.G.; Lodding, A.R.; Hench, L.L.; Newton, R.G.
	TITLE:	Surface Analyses of SRS Waste Glass Buried For Up to Two Years in Limestone in the United Kingdom
	PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management IV, G.G. Wicks, ed., American Ceramic Society, Westerville, OH, p. 653-662
	DATE:	

NO. 51	AUTHOR:	Pegg, I.L.; Greenman, W.; Guo, Y.; Muller, I.S.; Mohr, R.K.; Macedo, P.B.; Grant, D.C.; Mullik, P.R.
	TITLE:	Development of a Combined Soil Wash/In-Furnace Vitrification System for Soil Remediation at DOE Sites
	PUBLICATION:	First International Mixed Waste Symposium, ASME
	DATE:	8/1/91
NO. 52	AUTHOR:	Petit, J.C.; Mea, Della G.; Dran, J.C.; Magnathier, M.C.; Mando, P.A.; Paccagnella, A.
	TITLE:	Hydrated-Layer Formation During Dissolution of Complex Silicate Glasses and Minerals
	PUBLICATION:	Geochim-Cosmochim. Acta, 54, pp. 1941-1955
	DATE:	1/1/90
NO. 53	AUTHOR:	Phinney, D.L.; Ryerson, F.J.; Oversby, V.M.; Lanford, W.A.; Aines, R.D.; Bates, J.K.
	TITLE:	Integrated Testing of the SRL-165 Glass Waste Form
	PUBLICATION:	Material Research Society Symposium Proceedings, 84, pp. 433-446
	DATE:	1/1/86
NO. 54	AUTHOR:	Plodinec, M.J.
	TITLE:	Viscosity of Glasses Containing Simulated Savannah River Plant Waste
	PUBLICATION:	Savannah River Laboratory, DP-1507
	DATE:	8/1/78
NO. 55	AUTHOR:	Pye, L.D.
	TITLE:	The Physical and Thermal Properties of Simulated Nuclear Waste Glasses and Their Melts
	PUBLICATION:	Savannah River Lab DPST-85-397
	DATE:	2/1/85
NO. 56	AUTHOR:	Ramsey, A.A.
	TITLE:	EPA Tests of Simulated DWPF Waste Glass-U
	PUBLICATION:	WSRC-TR-90-22, InterOffice Memo to M.J. Plodinec
	DATE:	
NO. 57	AUTHOR:	Ramsey, W.G.; Taylor, T.D.; Jantzen, C.M.
	TITLE:	Predictive Modeling of Leachate pH for Simulated High Level Waste Glass
	PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management, pp. 105-114
	DATE:	4/29/91

NO. 58	AUTHOR:	Roberts, F.P.; Turcotte, R.P.; Weber, W.J.
	TITLE:	Materials Characterization Center, Workshop on the Irradiation Effects in Nuclear Waste Forms - Summary Report
	PUBLICATION:	US DOE Report, PNL-3588, Pacific Northwest Laboratory, Richland, WA
	DATE:	1/1/81
NO. 59	AUTHOR:	Ross, W.A.; Lokken, R.O.; May, R.P.; Roberts, F.P.; Timmerman, C.L.; Treat, R.L.; Westik, J.H.
	TITLE:	Comparative Assessment of TRU Waste Forms and Processes. Vol. I Waste Form and Process Evaluations
	PUBLICATION:	US DOE Report PNL-4428 Vol. 1
	DATE:	9/1/81
NO. 60	AUTHOR:	Savannah River Laboratory
	TITLE:	Environmental Assessment, Waste Form Selection for SRP High-Level Waste
	PUBLICATION:	US DOE, DOE/EA-0179
	DATE:	7/1/82
NO. 61	AUTHOR:	Schreiber, H.D.; Sisk, E.D.; Schreiber, C.W.; Burns, J.K.
	TITLE:	Solubilities of Nickel and Cobalt Chalcogenides in a Nuclear Waste Glass
	PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management, pp. 213-222
	DATE:	4/29/91
NO. 62	AUTHOR:	Schumacher, R. F.
	TITLE:	DWPF Batch 2, Waste Glass Investigations
	PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management, G.G. Wicks, ed., pp. 453-463
	DATE:	5/1/91
NO. 63	AUTHOR:	Shade, J.W.; Thompson, L.E.; Kindle, C.H.
	TITLE:	In Situ Vitrification of Buried Waste Sites
	PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management, G.G. Wicks, ed., American Ceramic Society, Westerville, OH, pp. 633-640
	DATE:	

NO. 64	AUTHOR:	Shenkler, E.S.; Graham, S.; Greenhut, V.A.
	TITLE:	Secondary Lead Smelter Slags: Minimizing Lead Release Levels
	PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management IV, G.G. Wicks, ed., American Ceramic Society, Westerville, OH, pp. 75-84
	DATE:	4/29/91
NO. 65	AUTHOR:	Slate, S.C.; Ross, W.A.; Partain, W.L.
	TITLE:	Impact Testing of Vitreous Simulated High-Level Waste in Canisters
	PUBLICATION:	USDOE BNWL-1903
	DATE:	5/1/75
NO. 66	AUTHOR:	Smith, D.K.
	TITLE:	Mineralogical, Textural and Compositional Data on the Alteration of Basaltic Glass From Kilauea, Hawaii to 300°C: Insights to the Corrosion of Borosilicate Glass
	PUBLICATION:	Material Research Society Symposium Proceedings, 212, pp. 115-121
	DATE:	1991
NO. 67	AUTHOR:	Smith, M.E.
	TITLE:	Travel Report - Summary of Talk Given at the SAIC OTD Thermal Working Meeting in Salt Lake City
	PUBLICATION:	Savannah River Lab, WSRC-RP-91-1092
	DATE:	10/30/91
NO. 68	AUTHOR:	Smith, T.H.; Ross, W.A.
	TITLE:	Impact Testing of Vitreous Simulated High-Level Waste in Canisters
	PUBLICATION:	USDOE BNWL-1903
	DATE:	5/1/75
NO. 69	AUTHOR:	Soper, P.D.; Walker D.D.; Plodinec, M.J.; Roberts, G.J.; Lightner, L.F.
	TITLE:	Optimization of Glass Composition for the Vitrification of Nuclear Waste
	PUBLICATION:	American Ceramic Society, Bulletin, Vol. 62, No. 9, pp. 1013-1028, DP-MS-81-108
	DATE:	9/1/83

NO. 70 AUTHOR: Stone, J.A.
TITLE: An Experimental Comparison of Alternative Solid Forms for Savannah River High-Level Wastes
PUBLICATION: Scientific Basis for Nuclear Waste Management., Annual Meeting of the Materials Research Society, DDP-MS-81-102
DATE: 11/16/81

NO. 71 AUTHOR: Stone, J.A.; Allender, J.S.; Gould, T.H.
TITLE: Comparison of Properties of Borosilicate Glass and Crystalline Ceramic Forms for Immobilization of Savannah River Plant Waste
PUBLICATION: USDOE Savannah River Lab., DP-1627
DATE: 4/1/82

NO. 72 AUTHOR: Taylor, R.F.
TITLE: Chemical Engineering Problems of Radioactive Waste Fixation by Vitrification
PUBLICATION: Chemical Engineering Science, Vol. 40, No. 4, pp. 541-569
DATE: 1985

NO. 73 AUTHOR: Van Iseghem, P.; Grambow, B.
TITLE: The Long-Term Corrosion and Modeling of Two Simulated Belgian Reference High-Level Waste Glasses
PUBLICATION: Material Research Society Symposium Proceedings, 112 , pp. 631-639
DATE: 1/1/88

NO. 74 AUTHOR: Vernaz, E.Y.; Gordon, N.
TITLE: Key Parameters of Glass Dissolution in Integrated Systems
PUBLICATION: Material Research Society Symposium Proceedings, 212, pp. 19-30
DATE: 1/1/91

NO. 75 AUTHOR: Volf, M.B.
TITLE: Chemical Approach to Glass
PUBLICATION: Book, Glass Science and Technology, 7 Elsevier, New York
DATE: 1/1/84

NO. 76 AUTHOR: Weber, W.J.; Turcotte, R.P.
TITLE: Materials Characterization Center, Second Workshop on Irradiation Effects in Nuclear Waste Forms, Summary Report
PUBLICATION: USDOE, PNL-4121
DATE: 1/1/82

NO. 77	AUTHOR:	Wicks, G.G.
	TITLE:	Nuclear Waste Glasses
	PUBLICATION:	Treatise on Materials Science and Technology, Vol. 26 Glass IV, pp. 57-118
	DATE:	1/1/85
NO. 78	AUTHOR:	Wicks, G.G.; Bickford, D.F.
	TITLE:	High Level Radioactive Waste - Doing Something About It
	PUBLICATION:	DuPont Savannah River Lab DP-1777
	DATE:	3/1/89
NO. 79	AUTHOR:	Wicks, G.G.; Stone, J.A.; Chandler, G.T.; Williams, S.
	TITLE:	Long-Term Leaching Behavior of Simulated Savannah River Plant Waste Glass
	PUBLICATION:	Savannah River Lab, DP-1728
	DATE:	8/1/86
NO. 80	AUTHOR:	Williams, J.P.; Wicks, G.G.; Clark, D.E.; Lodding, A.R.
	TITLE:	Analyses of SRS Waste Glass Buried in Granite in Sweden and Salt in the United States
	PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management IV, G.G. Wicks, et al., eds., pp. 663-674, American Ceramic Society, Westerville, OH
	DATE:	5/91

GLASS SUMMARIES **NO. 1**

TITLE: Summary of Properties for Borosilicate Waste Glasses

AUTHOR:

PUBLICATION:

DATE:

ORGANIZATION:

SUMMARY:

Waste Form:	Glass, borosilicate
Waste Type:	High level radioactive defense waste
Waste Loading:	Nominal 28 wt% from insoluble waste, 8 wt% from soluble
Development Status:	Mature after extensive testing
Compressive Strength:	550 MPa (80,000 psi)
Thermal Stability:	Control cooling to limit fracture, little change at T<500°C.
Radiation Stability:	No change due to self irradiation for 1 million years
Biological Stability:	Inert
Leach Resistance:	See conclusions
Immersion Stability:	--
Free Liquids:	No free liquids
Chemical Durability:	Excellent
Compositional Flexibility:	Limits on certain oxides, metals, redox, and salts
Gas Generation:	No gas release-simulated waste
RCRA Compliance:	Passes TCLP - all species below detection limit
Conclusions:	MCC-1, < 1 g/m^2 day PCT norm. Release boron <1 g/l; leach resistance influenced by glass composition, pH of leachate, temperature, SA/V and environment. Not affected by canister. Identical results for radioactive glasses.

GLASS SUMMARIES **NO. 2**

TITLE: A State-of-the-Art Review of Materials Properties of Nuclear Waste Forms

AUTHOR:

PUBLICATION: USDOE, PNL-3802

DATE: April 1, 1981

ORGANIZATION: Pacific Northwest Laboratory, Battelle

SUMMARY: Report is a state-of-the-art review of materials properties of nuclear waste forms for HLW. Physical properties include density, thermal conductivity and expansion, mechanical, chemical durability, radiation effects, thermal stability, etc. Waste forms include cement, ceramics, and glass.

Waste Form:	Glasses, high and low fire ceramics, composites,
Waste Type:	High level radioactive waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	Tensile: cement ~8, ceramic 8-30, glass 50 MPa
Thermal Stability:	--
Radiation Stability:	Density change: glass ±1 %; no change in leach rate
Biological Stability:	--
Leach Resistance:	Cement 10^{-3}, ceramics 10^{-7} to 10^{-8}, glass 10^{-4} to 10^{-7} g/cm^2day
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	A review of literature on waste forms prior to 1981.

GLASS SUMMARIES **NO. 3**

TITLE:	Vitrification Technologies for Treatment of Hazardous and Radioactive Waste
AUTHOR:	
PUBLICATION:	EPA/625/R-92/002 U.S. EPA, Center for Environmental Research Information, Cincinnati, OH 45268
DATE:	May 1, 1992
ORGANIZATION:	U.S. Environmental Protection Agency, Office of Research and Development
SUMMARY:	This is a handbook on the theory of vitrification processing and provides an overview of the applications and limitations of vitirification waste treatment. Chapters cover glass structure, vitrification processes, waste types, product characteristics, offgas treatment, capabilities and limitations, physical and chemical testing, and process evaluation.

Waste Form:	Glass
Waste Type:	Hazardous and radioactive waste
Waste Loading:	Varied
Development Status:	Varied
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	A good review of vitrification technology and products for hazardous and radioactive wastes. Strong on ISV.

GLASS SUMMARIES **NO. 4**

TITLE: Initial Demonstration of the DWPF Vitrification Process and Product Control Strategy Using Actual Radioactive Waste

AUTHOR: M.K. Andrews; N.E. Bibler; C.M. Jantzen; D.C. Beam

PUBLICATION: Ceramic Transactions, Nuclear Waste Management IV, Vol. 23, pp. 569-576

DATE: April 29, 1991

ORGANIZATION: American Ceramic Society, Westerville, Ohio

SUMMARY: To test the DWPF control algorithms, actual radioactive waste was melted in a shielded joule-heated melter facility at SRS and the resulting glass evaluated. Algorithms were used to control glass properties. Predicted values agreed reasonably well with measured values.

Waste Form: Glass, borosilicate
Waste Type: High level radioactive defense waste (actual)
Waste Loading: Nominal 28 wt%
Development Status: Mature
Compressive Strength: --
Thermal Stability: --
Radiation Stability: --
Biological Stability: --
Leach Resistance: See summary
Immersion Stability: --
Free Liquids: See summary
Chemical Durability: --
Compositional Flexibility: --
Gas Generation: --
RCRA Compliance:
Conclusions:

Properties	Predicted	Measured
Viscosity	64.8 P	<100 POISE
Liquidus	1005°C	<1050 °C.
Boron Rel.	26 ppm	69-48 ppm
Sodium Rel	50 ppm	122-88 ppm

The glass algorithms can be used to control actual radioactive glass vitrification. The glass was pourable indicating its viscosity was < 100 Poise as predicted. There were few spinel crystals indicating that the glass liquidus was less than 10,500°C as predicted. The durability of the glass was less than that predicted by the free energy of hydration model

GLASS SUMMARIES **NO. 5**

TITLE:	Interim Milestone HWVP-86-VI122C - Report on Composition Variability Testing Conducted for the HWVP
AUTHOR:	S.O. Bates; W. M. Bowen
PUBLICATION:	HWVP-86-VI 122C Final Report
DATE:	March 1, 1987
ORGANIZATION:	Pacific Northwest Laboratory
SUMMARY:	Scoping studies were conducted on the variation of certain oxides within a reference HWVP borosilicate glass.

Waste Form:	Glass, borosilicate
Waste Type:	High level radioactive defense waste
Waste Loading:	20 to 30 wt%
Development Status:	Intermediate
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	MCC-1 @ 90°C 28 day < 1 g/m^2 day
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Scoping tests confirmed that wide variations in composition can be accommodated in the reference glass. The following components will be included in future glass studies: waste level, zirconium, sodium, iron, aluminum and silicon.

GLASS SUMMARIES **NO. 6**

TITLE:	The Hydration Process of Nuclear Waste Glass: An Interim Report
AUTHOR:	J. K. Bates; L. J. Jardine; M.J. Steindler
PUBLICATION:	Argonne National Lab Report ANL 82-11
DATE:	January 1, 1982
ORGANIZATION:	Argonne National Laboratory
SUMMARY:	Reaction of glass in water vapor at 120-240°C results in formation of secondary phases.

Waste Form:	Borosilicate glass (SRL 211, SRL 131)
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Decreases as secondary phases form
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Hydration - aging of glass in repository important prior to possible contact with liquid water. Aging will decrease glass durability.

GLASS SUMMARIES **NO. 7**

TITLE:	The Application of Neutron Activation Analysis to the Title: Determination of Leach Rates of Simulated Nuclear Waste Forms
AUTHOR:	J.K. Bates; L. J. Jardine; K.F. Flynn; M.J. Steindler
PUBLICATION:	Argonne National Lab Report
DATE:	January 1, 1981
ORGANIZATION:	Argonne National Laboratory
SUMMARY:	Leach tests on borosilicate glasses that were neutron-activated and analysis of activation products by gamma spectroscopy (plus alpha-beta spectroscopy)

Waste Form:	Borosilicate glass (PNL 76-68 SRL 211)
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Stable after neutron activation
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Technique not suitable for B or Si analysis.

GLASS SUMMARIES **NO. 8**

TITLE:	Fifth In Situ Vitrification Engineering-Scale Test of Simulated INEL Buried Waste Sites
AUTHOR:	T.M. Bergsman; J.W. Shade; R.K. Farnsworth
PUBLICATION:	Battelle, PNL-8152, Prepared for USDOE
DATE:	June 1, 1992
ORGANIZATION:	Battelle, PNL
SUMMARY:	An in-situ vitrification of assorted sealed cans containing hazardous materials was carried out. The vitrified glass product passed the TCLP. Soil samples were also analyzed. No soil sample contained hazardous levels of organics and only one soil sample contained mercury above TCLP limits.

Waste Form:	Glass
Waste Type:	Soil and cans of hazardous waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Samples of glass and the surrounding soil were tested by TCLP. Only one sample contained toxic material above TCLP limits.

GLASS SUMMARIES **NO. 9**

TITLE:	The Product Consistency Test and its Role in the Waste Glass Acceptance Process for DWPF Glass
AUTHOR:	N.E. Bibler; C. M. Jantzen
PUBLICATION:	Waste Management '89, Vol.1, R.G. Post, ed. pp. 743-749
DATE:	January 1, 1989
ORGANIZATION:	University of Arizona, Tucson, AZ
SUMMARY:	Development of the Product Consistency Test (PCT) for radioactive waste glass. Reproducibility 2 - 3% for a single investigator and ~8% for different investigators.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	--
Development Status:	Submitted to ASTM
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--

Conclusions:

Leach Test:	PCT	Glass	DWPF
Leach Results:	131	Rad 200R	Start-up
NL (gm/l)*	1.10	1.05	0.95

* Normalized Log Boron Concentration

GLASS SUMMARIES **NO. 10**

TITLE:	Materials Interactions Relating to Long-Term Geologic Disposal of Nuclear Waste Glass
AUTHOR:	N.E. Bibler; C.M. Jantzen
PUBLICATION:	Scientific Basis for Nuclear Waste Management X, J.K. Bates, ed., pp. 47-66, Materials Research Society, Pittsburg
DATE:	January 1, 1987
ORGANIZATION:	Materials Research Society
SUMMARY:	Interactions between various materials in canister, overpack, etc.; the ground water; and the geologic mineral in oxic and anoxic conditions. The geologies reviewed are tuff, salt, basalt, and granite.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	--
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Leach resistance influenced by changes in pH due to radiation.
Biological Stability:	--
Leach Resistance:	Influenced by certain metals, Eh, pH, and mineral system
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--

Conclusions:

	Tuff	Salt	Basalt & Granite
Rock	None	None	Changes Eh
S. Steel	None	None	None
Iron overpack	-----	Inc. Leach.	May Inc. Leach.
Radiation	Changes pH	Changes Eh	None

GLASS SUMMARIES

NO. 11

TITLE:	Application of High Level Waste-Glass Technology to the Volume Reduction and Immobilization of TRU, Low Level, and Mixed Wastes
AUTHOR:	D.F. Bickford; M.E. Smith; P.M. Allen; J.P. Faraci; C.A. Langton; K.Z. Wolf
PUBLICATION:	Proceedings of Waste Management '91, R.G. Post, ed., Tucson, AZ, pp. 537-545
DATE:	January 1, 1991
ORGANIZATION:	
SUMMARY:	The EPA has designated vitrification as the "Best Developed Available Technology" for immobilization of high-level nuclear waste. Recent EPA announcements indicate the agency is considering long-term waste immobilization as a preferred mode of treatment for many types of hazardous waste. It was concluded that a program for adaptation of HLW vitrification to other wastes is clearly needed, and would have a high confidence of making major impact.

Waste Form:	Glass, borosilicate
Waste Type:	Low level mixed wastes, mixed TRU waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Description of stirred glass melter. Low level mixed wastes which require permanent isolation are good candidates for vitrification. Examples of waste types are presented.

GLASS SUMMARIES **NO. 12**

TITLE:	Control of Radioactive Waste Glass Melters: I, Preliminary General Limits at Savannah River
AUTHOR:	D.F. Bickford; A.A. Ramsey; C.M. Jantzen; K.G. Brown
PUBLICATION:	Journal of the American Ceramic Society, Vol. 73, 10, pp. 2896-2902
DATE:	October 1, 1990
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	Discusses DWPF melter control considerations, e.g., melter temperature, glass composition, product durability, waste loading limits, glass redox control, and glass cooling requirements.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	Nominal loading 28 wt%, (< 30 wt%)
Development Status:	Mature, extensive testing scale melters, simulated and radioactive feed
Compressive Strength:	--
Thermal Stability:	Cooling of canister controlled to prevent devitrification and cracking.
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Greater than environmental assessment glass (131/TDS)
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	Certain oxides and salts will be limited by control system
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	TiO_2 <1.0 wt% of glass, $S0_4$ <0.4 wt%, Cr_2O_3 <0.3 wt%, $P0_4$ < 3.0 wt%, NaF < 0.1 wt%, NaCl < 0.6 wt%, Fe(II)/Fe(III)< 0.5

GLASS SUMMARIES

NO. 13

TITLE:	Control of Radioactive Waste Glass Melters: II, Residence Time and Melt Rate Limitations
AUTHOR:	D.F. Bickford; P. Hrma; B.W. Bowan
PUBLICATION:	Journal of the American Ceramic Society, Vol. 73, 10, pp. 2903-2915
DATE:	October 1, 1990
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	Investigated melting behavior of simulated feeds with respect to foaming, homogenization, and glass quality. Introduces potential for stirred melting.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	--
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Waste glass melter size and residence times required by glass quality are much smaller than those used in current practice. Shorter residence times and lower melt temperatures are sufficient to develop durability similar to that of existing melters operating at 1,150°C.

GLASS SUMMARIES **NO. 14**

TITLE:	Advanced Radioactive Waste-Glass Melters
AUTHOR:	D.F. Bickford
PUBLICATION:	Presentation to American Ceramic Society, Tutorial Lecture on Novel Ceramic Processing/Nuclear Division, WSRC-RP-89-1174
DATE:	April 22, 1990
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	Discusses how technology developed for HLW might be used for other types of waste. A new type of stirred glass melter is introduced.

Waste Form:	Glass
Waste Type:	Simulated HLW, TRU, ^{248}Pu, U, RCRA, and mixed
Waste Loading:	--
Development Status:	Preliminary trial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	A new class of waste glass melters has been designed and proof of concept tests completed on simulated HLRW slurry. Melt rates have exceeded 155 kg/m^2/hr.

GLASS SUMMARIES

NO. 15

TITLE:	Control of Radioactive Waste-Glass Melters: Part 3 - Glass Electrical Stability
AUTHOR:	D.F. Bickford; R.C. Probst; M.J.Plodinec
PUBLICATION:	Advances in the Fusion of Glass, D.F. Bickford, ed., American Ceramic Society, Westerville, OH.
DATE:	June 1, 1988
ORGANIZATION:	American Ceramic Society
SUMMARY:	Pilot waste glass melters have shown a tendency for noble-metal accumulation on melter floors. These build-ups can affect joule heating of the melters.

Waste Form:	Glass, borosilicate
Waste Type:	High level radioactive defense waste
Waste Loading:	28 wt%
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Build-up of noble metals in the DWPF melter would not be sufficient to disrupt the joule heating in the melter. Discusses other elements, including mercury, sulfides, and silver.

GLASS SUMMARIES **NO. 16**

TITLE:	Large Scale Leach Testing of DWPF Canister Sections
AUTHOR:	D.F. Bickford; D.J. Pellarin
PUBLICATION:	Savannah River Laboratory, DP-MS-86-72
DATE:	December 1, 1986
ORGANIZATION:	International Symposium on the Scientific Basis for Nuclear Waste Management, Monitored Retrievable Storage
SUMMARY:	Leach testing of 24-in. diameter canister sections. MCC-1 leach conditions. Less than a factor of 3 increase in leachability resulted from the scale-up conditions of the test.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	Nominal 28 wt%
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	Glass was fractured on cooling
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Less than a factor of 3 increase in leachability results from combined scale-up, glass cracking, leached surface area estimation and surface roughness effects.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	28-day large scale test compared to typical MCC-1 test. Large scale within factor of 3 to MCC-1. Difference due to saw cutting of canister glass. Comparison of lab scale test to full size conditions.

GLASS SUMMARIES

NO. 17

TITLE:	A Borosilicate Glass for the Italian High-Level Waste: Characterization and Behavior
AUTHOR:	C. Cantale; S. Castelli; A. Donato; D.M. Traverso; P. Colombo; G. Scarinci
PUBLICATION:	Radioactive Waste Management and the Nuclear Fuel Cycle, 16 (1), pp. 25-47.
DATE:	January 1, 1991
ORGANIZATION:	ENEA, CRE-Casaccia, and Universita'di Padova
SUMMARY:	Description of processing, compositions, and initial testing of candidate waste forms for Italian radioactive waste

Waste Form:	Borosilicate glass
Waste Type:	--
Waste Loading:	Waste/glass=57%
Development Status:	Intermediate stage of development
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	MCC-1 NL(B) 28d=8g/m^2 91d=9g/m^2 for "BAZ-R" glass
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Describes testing of candidate waste forms, including physical characteristics and chemical leaching of laboratory glass and plant-produced BAZ glass.

GLASS SUMMARIES **NO. 18**

TITLE:	Chemical Durability of SRP Waste Glass - Saturation Effects and Influence of SA/V
AUTHOR:	G.T. Chandler; G.G. Wicks; R.M. Wallace
PUBLICATION:	Savannah River Laboratory, DP-MS-84-37
DATE:	April 24, 1984
ORGANIZATION:	American Ceramic Society
SUMMARY:	Investigated the ratio of the glass surface area (SA) to the volume of leachant (V). MCC-1 used as test.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	See summary
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Discusses the role of pH, saturation of chemical species, and SA/V on glass leach resistance.

GLASS SUMMARIES

NO. 19

TITLE:	State-of-the-Art of Waste Glass Melters
AUTHOR:	C. Chapman
PUBLICATION:	3rd International Symposium, Advances in Fusion and Processing of Glass, New Orleans, Louisiana
DATE:	May 1, 1992
ORGANIZATION:	Battelle, Pacific Northwest Laboratories
SUMMARY:	A review of types of melters under consideration for vitrification for both high level and low level mixed wastes.

Waste Form:	Glass
Waste Type:	High and low level mixed waste
Waste Loading:	25 to 50 wt%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The volumes of hazardous, nonhazardous, radioactive, and mixed wastes produced each year are large. Waste vitrification or transformation of waste into a nonleaching and useful secondary glass material is an environmentally attractive process.

GLASS SUMMARIES **NO. 20**

TITLE:	Evaluation of Vitrifying Municipal Incinerator Ash
AUTHOR:	C.C. Chapman
PUBLICATION:	Ceramic Transactions, Nuclear Waste Management IV, G.G. Wicks, ed., pp. 223-231.
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	Vitrifying incinerator ash is an attractive means of stabilizing the toxic materials. Vitrification provides a further volume reduction and produces a construction material. Vitrification provides an economic treatment method while providing an environmentally sound solution to a troublesome waste steam.

Waste Form:	Glass calcium aluminosilicate
Waste Type:	Incinerator ash, municipal
Waste Loading:	100% to 80% volume reduction
Development Status:	Initial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Vitrification of municipal incinerator ash provides an economic treatment method, while providing an environmentally sound solution to disposal of the waste stream.

GLASS SUMMARIES **NO. 21**

TITLE: Electric Melting of Nuclear Waste Glasses, State of the Art

AUTHOR: C.C. Chapman; J.M. Pope; S.M. Barnes

PUBLICATION: Journal of Non-Crystalline Solids, No. 84, pp. 226-240

DATE: January 1, 1986

ORGANIZATION: West Valley Nuclear Services Co.

SUMMARY: The paper reviews the design of melters used throughout the world. Includes the lessons learned and the problems associated with corrosion, crystalline sludge, reboil, and metal precipitation.

Waste Form:	--
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Discusses the liquid-fed ceramic, West Valley Demonstration, DWPF, PAMELA melter, Japanese vitrification, Hanford, and the U.K. Harwell melters. Problems with draining, corrosion, foaming, etc., are discussed.

GLASS SUMMARIES **NO. 22**

TITLE:	Chemical Durability and Related Properties of Solidified High-Level Waste Forms
AUTHOR:	Coordinated Research Programme of the Evaluation of Solidified High-Level Waste Form.
PUBLICATION:	IAEA Technical Report Series No. 257
DATE:	January 1, 1985
ORGANIZATION:	International Atomic Energy Agency
SUMMARY:	Review of waste glass/ceramic compositions, leach tests, and multicomponent effects (radiation, backfill, etc.) for international application.

Waste Form:	Borosilicate glass
Waste Type:	--
Waste Loading:	Effects of 10-30% on leaching are composition-dependent.
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

GLASS SUMMARIES **NO. 23**

TITLE:	WIPP/SRL In Situ Tests: MIIT Program - The Effects of Metal Package Components
AUTHOR:	J.F. Covington; G.G. Wicks; M.A. Molecke
PUBLICATION:	Ceramic Transactions, Nuclear Waste Management, Vol. 23, pp. 723-732
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	There were no significant effects observed on leaching of SRL Y waste glass due to the presence of 304L stainless steel.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	Nominal 28 wt%
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	See summary
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	See summary
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	No large effects observed on the leaching of SRL Y waste glass when leached in the presence of metals, including titanium, copper, nickel alloys, and several carbon steels. Metals such as A216 and lead corroded significantly.

GLASS SUMMARIES **NO. 24**

TITLE:	Modeling the Dissolution of Borosilicate Glasses for Radioactive Waste Disposal with the PHREEQE/GLASSOL Code: Theory and Practice
AUTHOR:	E. Curti
PUBLICATION:	PSI-Bericht Nr. 86
DATE:	January 1, 1991
ORGANIZATION:	Paul Scherrer Institute, Wurenlingen, Germany
SUMMARY:	Discusses Granbow model of silicic acid control of glass reaction rate and applies model to measured reactivity of British MW-glass at 90°C. Finds model requires too much curve fitting to define parameters to be acceptable.

Waste Form:	Borosilicate glass (MW) and ABS-118
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Long term MW=6 x 10^{-3}, ABS-118 = 1.31 x 10^{-3} g/m^2/day, deionized water, 90°C
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Current model (Granbow's version) requires too many ad hoc adjustments based on data to be modeled to be acceptable for long-term predictions.

GLASS SUMMARIES **NO. 25**

TITLE:	Cyclone Furnace for Vitrification of Contaminated Soil and Wastes
AUTHOR:	J.M. Czuczwa; H. Farzan; S.J. Vecci; J.J. Warchol
PUBLICATION:	1991 Incineration Conference Proceedings, pp. 613-620, Knoxville, TN
DATE:	May 1, 1991
ORGANIZATION:	Babcock & Wilcox Co.
SUMMARY:	Describes cyclone furnace which might be well-suited for treating high inorganic content hazardous wastes, e.g., soils.

Waste Form:	Slag
Waste Type:	Contaminated soils
Waste Loading:	100%
Development Status:	Early
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Passes TCLP
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Passes TCLP
Conclusions:	Furnace was able to melt soil at 150 lb/hr. Slag passed TCLP. Approximately 95% of soil was captured as slag. Had a severe problem with toxic metal volatility. This was probably due to dispersion of waste into cyclonic burner. Not a good approach to trying to encapsulate inorganic toxic waste.

GLASS SUMMARIES **NO. 26**

TITLE: R7T7 Glass Initial Dissolution Rate Measurements Using a High-Temperature Soxhlet Device

AUTHOR: F. Delege; J.L. Dussossoy

PUBLICATION: Materials Research Society Symposium Proceedings, 212, pp. 41-47

DATE: January 1, 1991

ORGANIZATION: CEA-CEN France

SUMMARY: Measure forward rate coefficient as function of temperature using Soxhlet from 90-250°C. Follows Arrhenius behavior with Ea=58-60 kJ/mol

Waste Form:	Borosilicate glass, R7T7
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	K_t = A exp ((-59k)/mol/RT)
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Rate coefficient follows Arrhenius behavior between 90 to 250°C with Ea=58 to 60 kJ/mol. Release of Li, Na, B, & Si non-stoichiometric but all linear in reaction time. Interpret Ea to indicate surface reaction control of rate.

GLASS SUMMARIES **NO. 27**

TITLE:	Natural Analogues: Their Application to the Prediction of the Long-Term Behavior of Nuclear Waste Forms
AUTHOR:	R.C. Ewing; M.J. Jercinovic
PUBLICATION:	Materials Research Society Symposium Proceedings, 84, pp. 67-83
DATE:	January 1, 1987
ORGANIZATION:	Department of Geology, University of New Mexico
SUMMARY:	Review of natural analogue approach to HLW problem and summary of experimental results through 1986

Waste Form:	Analogues for borosilicate glass
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Discusses tektite, rhyolitic, and basaltic glass analogies based on silica contents, comparisons of experimentally altered glass and naturally altered glass, primarily through secondary solids generated.

GLASS SUMMARIES **NO. 28**

TITLE:	Chemistry
AUTHOR:	J. Gafney
PUBLICATION:	Science News, pg. 172
DATE:	March 14, 1992
ORGANIZATION:	Argonne National Laboratory
SUMMARY:	Observed on a qualitative basis that humic acid may interact with borosilicate labware.

Waste Form:	Glass
Waste Type:	Humic acid
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	Humic acid may interact with borosilicate labware
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Humic acid may interact with borosilicate labware. Possible complexing agent.

GLASS SUMMARIES **NO. 29**

TITLE:	Performance Assessment of Glass as a Long-Term Barrier to the Release of Radionuclides into the Environment
AUTHOR:	B. Grambow; W. Lutze; R.C. Ewing; L.O. Werme
PUBLICATION:	Material Research Society Symposium Proceedings, 112
DATE:	January 1, 1988
ORGANIZATION:	HMI, UNM, SKB
SUMMARY:	Summarizes leaching test interpretation of JSS project based on Grambow's reaction model.

Waste Form:	Borosilicate glass JSS-A ABS-118
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Forward rate $1.5 g/m^2/d$ final rate $0.0025 g/m^2/d$ at 90°C
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	COGEMA glass sufficiently durable at flow rates <100 l/yr; glassol code (and his model) validated; long-term 'final rate' not well understood; backfill not effective barrier.

GLASS SUMMARIES **NO. 30**

TITLE:	Demonstrating Compliance with the Waste Acceptance Preliminary Specifications on Foreign Materials within DWPF Canistered Waste Forms
AUTHOR:	J.R. Harbour
PUBLICATION:	Proceedings of the 2nd International Seminar on Radioactive Waste Products, E. Warnecke, et al., eds., KFA Research Julich, FRG, WSRC-MS-90-98
DATE:	May 28, 1990
ORGANIZATION:	Westinghouse Savannah River Co.
SUMMARY:	Study of volatility of waste glass combined with new results of thermogravimetric analysis (TGA) experiments.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	Nominal 28 wt%
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	No organics or free liquid found
Chemical Durability:	--
Compositional Flexibility:	Highly reduced glass powder may absorb oxygen > 400°C
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	TGA results demonstrate that powdered waste glass samples can gain or loose weight upon heating. The weight loss is associated with adsorbed water loss while weight gain at 400°C may be associated with oxygen uptake of reduced species, e.g., iron. The volatility of these glass samples provides evidence that no free liquids, free gases, organics, or explosives are released upon heating the waste glass to its glass transition temperature.

TITLE:	The Determination of Pressure, Dewpoint, and Composition of the Gas Within the Free Volume of Canistered Waste Forms
AUTHOR:	J.R. Harbour; T.J. Miller; M.J. Whitaker
PUBLICATION:	WSRC-RP-90-1167
DATE:	January 1, 1990
ORGANIZATION:	Westinghouse Savannah River Co. Aiken, SC
SUMMARY:	The free volume in four simulated canistered waste forms produced during Scale Glass Melter Campaigns was examined after being hermetically sealed for 2 to 3 years. The internal gas pressure, dewpoint temperature and gas composition were determined.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	Nominal 28 wt%
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	Relative humidities in canister 5-20 %, no free water.
Chemical Durability:	No unexpected chemical compound(s) found within sealed containers.
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	No free liquids or unexpected chemical compounds were identified within the sealed containers after several years of storage. The simulated waste form does not volatilize or emit chemical compounds, including water, during storage.

GLASS SUMMARIES **NO. 32**

TITLE:	Evaluation of the Potential for Gas Pressurization and Free Liquid Accumulation in a Canister from the West Valley Demonstration Project
AUTHOR:	R.F. Hazelton; C.K. Thornhill; W.A. Ross
PUBLICATION:	Ceramic Transactions, Nuclear Waste Management, IV, Vol. 23, pp. 491-500
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	A full-scale canister from WVDP was tested to determine potential for gas generation (non-radiolytic) and liquid accumulation. Heated for eight weeks above glass transition temperature.

Waste Form:	--
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquid:	No free liquid detected (increase in H_20 of 0.00004 wt%)
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	No unusual gasses detected nor generation of pressure.
RCRA Compliance:	--
Conclusions:	Test did not generate any gas pressurization. Oxygen depleted. Carbon dioxide increased. No free water detected.

GLASS SUMMARIES **NO. 33**

TITLE:	Results of Vitrifying Fernald K-65 Residue
AUTHOR:	D.S. Janke; C.C. Chapman; R.A. Vogel
PUBLICATION:	Ceramic Transactions, Nuclear Waste Management, Vol. 23, pp. 53-61
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society, Westerville, OH
SUMMARY:	K-65 residue, which contains radium, uranium, daughter products, and heavy metals (lead), was vitrified on a bench-scale system which permitted analysis of the off-gas. TCLP, EP were measured.

Waste Form:	Glass, soda iron barium silicate
Waste Type:	Pitchblende residue, treated as TRU waste
Waste Loading:	Approximately 80 wt%; volume reduction 60%
Development Status:	Initial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	See conclusions
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	Reduced by factor of 33,000; limited to amount from surface of glass.
RCRA Compliance:	--
Conclusions:	K-65 residue tested "hazardous" by EP toxicity test, with radon emanation rate (52,400 $pCi/m^2/s$) after vitrification tested "non-hazardous" radon gas reduced by factor of 33,000 to 1.56 $pCi/m^2/s$.

GLASS SUMMARIES **NO. 34**

TITLE:	Solidification of Consolidated Incinerator Facility (CIF) Wastes in Soda-Lime-Silica (SLS) Glass: Use of Reactive Additives to Retain Hazardous and Heavy Metal Constituents
AUTHOR:	C.M. Jantzen
PUBLICATION:	Savannah River Lab, WSRC-TR-92-214, Rev. 0
DATE:	April 30, 1992
ORGANIZATION:	Westinghouse Savannah River Co.
SUMMARY:	Discusses the vitrification of CIF blowdown and bottom kiln ash waste with available silica sources to form a stable soda lime glass waste form. The stirred electric melter is recommended as the melter system.

Waste Form:	Glass, soda-lime
Waste Type:	Incinerator blow-down and ash, low level radioactive, hazardous, mixed
Waste Loading:	45 to 50 wt%
Development Status:	Preliminary
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Expected to pass TCLP
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	Wide variation in feed material
Gas Generation:	--
RCRA Compliance:	Expected to pass TCLP
Conclusions:	Vitrification suggested as a viable process for solidification of CIF blowdown and kiln ash waste. Only one additive, SiO_2, is necessary for vitrification.

GLASS SUMMARIES **NO. 35**

TITLE:	Thermodynamic Approach to Glass Corrosion
AUTHOR:	C.M. Jantzen
PUBLICATION:	Corrosion of Glass, Ceramics, and Ceramic Superconductors, Principles, Testing, Characterization and Applications, D.E. Clark and B.K. Zoitos, eds., pp. 153-215, Noves Publications, Park Ridge, NJ
DATE:	January 1, 1992
ORGANIZATION:	Savannah River Site
SUMMARY:	A review of theory of glass corrosion. Approaches glass corrosion from thermodynamic point of view. Discusses various parameter effects, e.g., SA/V, Eh, and pH.

Waste Form:	--
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Hydration thermodynamics have wide applicability to predict the durability of natural, ancient, modern, and nuclear waste glass. The predicted durabilities correlate with those observed in nature and give a means for interpolation of the long-term durability of nuclear waste glasses.

GLASS SUMMARIES **NO. 36**

TITLE:	First Principles Process-Product Models for Vitrification of Nuclear Waste: Relationship of Glass Composition to Glass Viscosity, Resistivity, Liquidus Temperature, and Durability
AUTHOR:	C.M. Jantzen
PUBLICATION:	Ceramic Transactions, Vol. 23, pp. 37-51, Nuclear Waste Management IV, G.G. Wicks, et al., eds.
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	Development of first principle models for viscosity, electrical conductivity, liquidus temperature, and durability.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	--
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The process/product models developed for the DWPF have been developed on first principle concepts of glass chemistry, solubility, precipitation, and thermodynamics. The models have been successfully used to control several Research Melter Campaigns at SRS (simulated and radioactive waste).

GLASS SUMMARIES **NO. 37**

TITLE:	Systems Approach to Nuclear Waste Glass Development
AUTHOR:	C.M. Jantzen
PUBLICATION:	Journal of Non-Crystalline Solids, 84, No. 1-3, pp. 215-225
DATE:	January 1, 1986
ORGANIZATION:	
SUMMARY:	A review and comparison among borosilicate, high-silica, and phosphate glasses indicated that borosilicate glass was most desirable for the immobilization of nuclear waste.

Waste Form:	Glass
Waste Type:	Nuclear waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	A system evaluation of aluminosilicate glasses indicates that they have superior product characteristics, but are difficult to process. Evaluation of phosphate glasses indicates that they have adequate to poor product characteristics and are difficult to process. Borosilicate glass exhibits favorable product performance and ease of processability.

GLASS SUMMARIES **NO. 38**

TITLE:	Nuclear Waste Glass Product Consistency Test (PCT)
AUTHOR:	C.M. Jantzen; N.E. Bibler
PUBLICATION:	Savannah River Site
DATE:	November 1, 1990
ORGANIZATION:	Westinghouse Savannah River Co. Aiken, SC
SUMMARY:	The PCT procedure as submitted to ASTM C26.13. The PCT is a method of quickly determining the durability and consistency of glasses. Proposed for use at DWPF.

Waste Form:	Glass
Waste Type:	--
Waste Loading:	--
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	7 day 90°C deionized water.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	A durability test, designated the Product Consistency Test (PCT) was developed for DWPF glass in order meet to the applicable waste acceptance specifications. The response of the PCT procedure was based on extensive testing with glasses of widely different compositions. The PCT was determined to be very reproducible, to yield reliable results rapidly and to be easily performed in shielded cell facilities with radioactive samples.

GLASS SUMMARIES **NO. 39**

TITLE:	The Product Consistency Test for the DWPF Wasteform
AUTHOR:	C.M. Jantzen; N.E. Bibler
PUBLICATION:	Proceedings of the 2nd International Seminar on Radioactive Waste Products, E. Odoj, et al., eds., pp. 609-622
DATE:	June 1, 1990
ORGANIZATION:	Kernforschunganlanger (KFA) Julich, FRG
SUMMARY:	Development of Product Consistency Test (PCT). Comparison to MCC-1 as well as other tests, results of round-robin evaluations.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	--
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Log norm. Boron compared to free energy of hydration, results of round-robin evaluation. Approximately 10% difference between laboratories.

GLASS SUMMARIES **NO. 40**

TITLE:	Leaching of Polyphase Nuclear Waste Ceramics: Microstructural and Phase Characterization
AUTHOR:	C.M. Jantzen; D.R. Clarke; P.E.D. Morgan; A.B. Harker
PUBLICATION:	Journal of the American Ceramic Society, Vol. 65, No. 6, pp. 292-300
DATE:	June 1, 1982
ORGANIZATION:	Rockwell International Science, Ctr.
SUMMARY:	The leaching of complex polyphase nuclear waste ceramics is described in the context of the geochemically established dissolution behavior of the constituent phases.

Waste Form:	Ceramic, tailored for SRS defense waste
Waste Type:	High-level defense waste
Waste Loading:	30 - 60 wt%
Development Status:	Initial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Dissolution was incongruent and controlled by the solubilities of the individual phases. Necessary to avoid intergranular glass phases due largely to trace amounts of silica and microcracking of the principle phases during processing.

GLASS SUMMARIES **NO. 41**

TITLE:	Thermodynamic Model of Natural, Medieval and Nuclear Waste Glass Durability
AUTHOR:	C.M. Jantzen; M.J. Plodinec
PUBLICATION:	Journal of Non-Crystalline Solids, 67, pp. 207-223
DATE:	January 1, 1984
ORGANIZATION:	Elsevier Science Publishers, North Holland, Amsterdam
SUMMARY:	A thermodynamic model of glass durability based on the hydration of "structural units" has been applied to natural glass, medieval window glasses, and glasses containing nuclear waste.

Waste Form:	Glass, general
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	See summary
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	A method of calculating glass durability based on the free energy of hydration is presented. The contribution of the redox level and alumina coordination must also be considered. Glass compositions which raise the pH of leachate above 10 must be corrected with an additional free energy term. Waste glass is compared to known glasses which were formed 500 to 0.5 million years ago.

GLASS SUMMARIES **NO. 42**

TITLE:	Comparison of Surface Layers Formed on Synthetic Basaltic Glass, French R7T7 and HMI Borosilicate Nuclear Waste Form Glasses-Materials Interface Interactions Tests-Waste Isolation Pilot Plant
AUTHOR:	M.J. Jercinovic; S.A. Kaser; R.C. Ewing; W. Lutze
PUBLICATION:	Material Research Society Symposium Proceedings, 176, pp. 355-362
DATE:	January 1, 1990
ORGANIZATION:	Department of Geology, University of New Mexico; HMI, Berlin
SUMMARY:	Analysis of secondary phases formed on basalt, R7T7, and HMI glasses reacted up to 2 years.

Waste Form:	Borosilicate glass, basalt as natural analogue
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Layer compositions reflect glass compositions, although some elements are incorporated from leachant.

GLASS SUMMARIES **NO. 43**

TITLE:	Basaltic Glasses From Iceland and the Deep Sea: Natural Analogues to Borosilicate Nuclear Waste-Form
AUTHOR:	M.J. Jercinovic; R.C. Ewing
PUBLICATION:	JSS 88-01
DATE:	January 1, 1988
ORGANIZATION:	Department of Geology, University of New Mexico
SUMMARY:	Provides characterization of reaction processes and products for reaction of natural basaltic glasses.

Waste Form:	Basalt glass as analogue for borosilicate glass
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Amorphous and crystalline products form on glass surface but do not protect underlying glass from further attack. Supports Grambow's hypothesis of two characteristic rate coefficients for initial rate in dilute solutions and final rate in "silica-saturated" solutions.

GLASS SUMMARIES **NO. 44**

TITLE:	Silicate Glasses
AUTHOR:	W. Lutze
PUBLICATION:	Radioactive Waste Forms for the Future, W. Lutze, R.C. Ewing, eds., Elsevier Science Publishers, B.V.
DATE:	January 1, 1988
ORGANIZATION:	Hahn-Meitner-Institute, Berlin
SUMMARY:	Review of silicate glasses as used in high-level waste disposal. Review of mechanical and chemical properties of U.S. and foreign glasses.

Waste Form:	Borosilicate glass, many different compositions discussed
Waste Type:	Reprocessed high-level waste
Waste Loading:	--
Development Status:	Advanced
Compressive Strength:	--
Thermal Stability:	Glass will crack as it cools
Radiation Stability:	Radiation effects in glass are small, in leachate lead to modest increase
Biological Stability:	--
Leach Resistance:	In general 0.5-5 $g/m^2/d$ at 90° deionized water initially
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	Nitric acids from radiolysis increase rate slightly; phase separation possible at high waste loadings
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Glass composition determined primarily by processing techniques; overloading with waste may lead to phase separation; glass will fracture as it cools; radiation does not significantly affect glass durability (enhancement less than 5 times); different glasses have different corrosion rates, which decrease with time; solid alteration products may affect reaction.

GLASS SUMMARIES **NO. 45**

TITLE:	Radioactive Waste Forms for the Future
AUTHOR:	W. Lutze; R.C. Ewing
PUBLICATION:	Book, Elsevier Science Publishers, B.V., pp. 699-739
DATE:	January 1, 1988
ORGANIZATION:	
SUMMARY:	A review of high level waste forms. Compares borosilicate glass and other glasses, Synroc and other ceramics, and FUETAP cement. Provides a summary of physical and chemical properties.

Waste Form:	Glass, borosilicate, Synroc, tailored ceramics, FUETAP
Waste Type:	High-level defense waste
Waste Loading:	10-60 wt%
Development Status:	Varied
Compressive Strength:	Ceramic~550 MPa; FUETAP ~20 MPa
Thermal Stability:	--
Radiation Stability:	%vol change: borosilicate ±1.5, Synroc +8
Biological Stability:	--
Leach Resistance:	Borosilicate < 1 $g/m^2/d$; difficult to compare forms due to radiation effects
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Borosilicate: large data base, corrosion mechanism well understood, long term corrosion validated by natural glasses, industrial scale fabrication has been demonstrated. Synroc: well-characterized, more stable at elevated temperatures in hydrothermal environment better mechanical integrity, no flow rate dependence for leaching, natural analogues available.

GLASS SUMMARIES **NO. 46**

TITLE: Chemical Corrosion of Lead-Iron Phosphate Glass

AUTHOR: W. Lutze; B. Grambow

PUBLICATION: In-process

DATE:

ORGANIZATION: Hahn-Meitner Institute, Berlin

SUMMARY:

Waste Form:	Phosphate glass, lead-iron
Waste Type:	LWR commercial waste
Waste Loading:	6.4 wt%
Development Status:	Initial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Max rate 0.05 $g/m^2/day$ (MCC-1, 90°C, deionized water)
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Leach rate controlled by $Pb_3(PO_4)^2$. Lead-iron phosphate glass more stable than borosilicate due to lower solubility of $Pb_3(PO_4)^2$ compared to H_4SiO_4, which controls rate of borosilicate reaction.

GLASS SUMMARIES **NO. 47**

TITLE:	A Comparison of the Behavior of Vitrified HLW in Repositories in Salt, Clay, and Granite. Part II: Results
AUTHOR:	J.A.C. Marples; W. Lutze; M. Kawanishi; P. Van Iseghem
PUBLICATION:	Material Research Society Symposium Proceedings, 176, pp. 275-282
DATE:	January 1, 1990
ORGANIZATION:	
SUMMARY:	Results of round-robin with R7T7 glass at 900°C in salt, clay, or granite at 90°C.

Waste Form:	Borosilicate glass
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Glass corroded at about the same rate in clay and granite systems, but about 10 times faster in salt. Agreement between labs on absolute releases is poor.

GLASS SUMMARIES **NO. 48**

TITLE:	Comparison of SRP High-Level Waste Disposal Costs for Borosilicate Glass and Crystalline Ceramic Waste Forms
AUTHOR:	W.R. McDonell
PUBLICATION:	DuPont, Savannah River Laboratory, DPST-82-346
DATE:	April 1, 1982
ORGANIZATION:	DuPont, Savannah River Laboratory
SUMMARY:	Comparison of costs for immobilization and disposal HLW indicates that the borosilicate waste form is less costly than the crystalline waste form. Waste disposal for ceramic less costly due to fewer canisters, however not sufficient to offset the higher development and processing costs.

Waste Form:	Glass/borosilicate - ceramic/Synroc-D
Waste Type:	High level radioactive defense waste
Waste Loading:	Glass - 28 wt%; ceramic - 65 wt% (52% after Al wash)
Development Status:	Glass - mature; ceramic - intermediate
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Costs dependent on size of ceramic body, development costs. Must consider all costs, intermediate storage, shipping, final storage, and monitoring. The cost reductions due to lesser number of ceramic canisters did not offset the higher development and processing costs.

GLASS SUMMARIES

NO. 49

TITLE:	A Comparison of the Behavior of Vitrified HLW in Repositories in Salt, Clay, and Granite, I: Experimental
AUTHOR:	L.A. Mertens; W. Lutze; J.A.C. Marples; P. Van lseghem; E. Vernaz
PUBLICATION:	Material Research Society Symposium Proceedings, 176, pp. 267-274
DATE:	January 1, 1990
ORGANIZATION:	
SUMMARY:	Round-robin results for leach tests with R7T7 glass at 90°C.

Waste Form:	Borosilicate glass
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Comparison of results from different labs shows large differences in highly soluble species of B, Li, and Mo.

GLASS SUMMARIES **NO. 50**

TITLE:	Surface Analyses of SRS Waste Glass Buried for up to Two Years in Limestone in the United Kingdom
AUTHOR:	C.G. Namboodri; G.G. Wicks; A.R. Ledding; L.L. Hench; R.G. Newton
PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management IV, G.G. Wicks, ed., American Ceramic Society, Westerville, OH, pp. 653-662
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society
SUMMARY:	Evaluation of borosilicate glass after one and two years at ambient temperature. For all samples, the glass interaction zone was less than 1 micron.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high-level radioactive waste.
Waste Loading:	28 wt%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Less than one micron interaction layer after two years at ambient temperature.

GLASS SUMMARIES **NO. 51**

TITLE:	Development of a Combined Soil Wash/In-Furnace Vitrification System for Soil Remediation at DOE Sites
AUTHOR:	I.L. Pegg; W. Greenman; Y. Guo; I.S. Muller; R. K. Mohr; P.B. Macedo; D.C. Grant; P.R. Mullik
PUBLICATION:	First International Mixed Waste Symposium, ASME
DATE:	August 1, 1991
ORGANIZATION:	Duratek Corp, CUA, Westinghouse
SUMMARY:	Vitrification and soil washing technologies are briefly reviewed and compared to other technologies for remediation of contaminated soils and sludges.

Waste Form:	Glass, borosilicate
Waste Type:	Low-level, mixed, and TRU
Waste Loading:	60-80 % loading blended streams
Development Status:	Initial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	While the costs associated with waste treatment are important components in a comparison of treatment technologies, they represent only a part of the total costs for site remediation. Disposal and long-term monitoring must also be considered. Recommends washing of contaminated soils and slurries, capture of radioactive and hazardous materials, followed by vitrification.

GLASS SUMMARIES **NO. 52**

TITLE:	Hydrated-Layer Formation During Dissolution of Complex Silicate Glassses and Minerals
AUTHOR:	J.C. Petit; D.G. Mea; J.C. Dran; M.C. Maganthier; P.A. Mando; A. Paccagnelia
PUBLICATION:	Geochim-Cosmochim. Acta, 54, pp. 1941-1955
DATE:	January 1, 1990
ORGANIZATION:	SESD/LECALT, CEN-FAR, France
SUMMARY:	Study of the dissolution behavior of three complex silicate glasses and five crystalline silicates after implantation of Pb ions to produce dislocations.

Waste Form:	Borosilicate glass
Waste Type:	Simulated
Waste Loading:	None
Development Status:	Experimental
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Hydrated layers form on all samples in which heavy elements accumulate.

GLASS SUMMARIES **NO. 53**

TITLE: Integrated Testing of the SRL-165 Glass Waste Form

AUTHOR: D.L. Phinney; F.J. Ryerson; V.M. Oversby; W.A. Lanford; R.D. Aines; J.K. Bates

PUBLICATION: Material Research Society Symposium Proceedings, 84, pp. 433-446

DATE: January 1, 1986

ORGANIZATION: Lawrence Livermore National Laboratory, Argonne National Laboratory

SUMMARY: Mass-balance analyses of reacted SRL-165 glass to account for alteration layer composition, tuff rock and steel vessel surfaces, and leachate.

Waste Form:	Borosilicate glass, SRL-165
Waste Type:	Doped with ^{237}Np, ^{239}Pu and ^{242}Am
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	1.5 to 3.0 micron/yr at 90°C at S.A.=1/10m in J-13 solution
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Glass reacts via ion exchange, followed by surface dissolution. Actinides sorbed onto teflon and steel vessel surfaces. U and Li diffused into tuff.

GLASS SUMMARIES **NO. 54**

TITLE: Viscosity of Glasses Containing Simulated Savannah River Plant Waste

AUTHOR: M.J. Plodinec

PUBLICATION: Savannah River Laboratory, DP-1507

DATE: August 11, 1978

ORGANIZATION: E.I. DuPont, Savannah River Laboratory, Aiken, SC

SUMMARY: The viscosity of glass melts containing four simulated sludge types and two frits were measured over the temperature range 750-1200°C.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	25 to 30 wt%
Development Status:	Preliminary (1978)
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Limits for viscosity, sludge loading, and devitrification were defined. Melts containing devitrification were found to be non-Newtonian.

GLASS SUMMARIES **NO. 55**

TITLE:	The Physical and Thermal Properties of Simulated Nuclear Waste Glasses and Their Melts
AUTHOR:	L.D. Pye
PUBLICATION:	Savannah River Laboratory, DPST-85-397
DATE:	February 1, 1985
ORGANIZATION:	Alfred University
SUMMARY:	The physical and thermal properties of three simulated nuclear waste glasses (165), high-iron, TDS, and high-alumina were measured.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading	Nominal 28 wt%
Development Status:	Mature
Compressive Strength:	M.O.R. 3700 to 6200 psi
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Density @ 23°C, 2.6 to 2.8; coefficient of linear expansion <300°C 9.9 to 10 ppm; also, values for thermal diffusivity, Young's modulus, shear modulus, Poisson's ratio, specific heat, and viscosity.

GLASS SUMMARIES **NO. 56**

TITLE:	EPA Tests of Simulated DWPF Waste Glass-U
AUTHOR:	A.A. Ramsey
PUBLICATION:	WSRC-TR-90-22, Inter Office Memo to M.J. Plodinec.
DATE:	January 10, 1990
ORGANIZATION:	Westinghouse Savannah River Co.
SUMMARY:	The simulated DWPF waste glasses tested passed both the EP Toxicity and the TCLP tests. The glasses were prepared by doping two to three times the expected amounts of Cr, Pb, Ba, Ag, Se, and Cd. The resulting material is not a hazardous waste.

Waste Form:	Simulated high-level waste borosilicate glass.
Waste Type:	Simulated radioactive, actual hazardous elements
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Passed TCLP and EP Tox tests
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Non-hazardous
Conclusions:	Simulated high level waste form is not a hazardous waste.

GLASS SUMMARIES **NO. 57**

TITLE:	Predictive Modeling of Leachate pH for Simulated High Level Waste Glass
AUTHOR:	W.G. Ramsey; T.D. Taylor; C.M. Jantzen
PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management, pp. 105-114
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	A methodology is proposed for predicting the equilibrium pH of leachates from PCT experiments in deionized water. Glasses in the SiO_2-Al_20_3-B_20_3-Fe_2O_3-CaO-Na_2O system were tested.

Waste Form:	Glass
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leach resistance largely dependent on the pH of leachate
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	It was possible to predict the equilibrium pH based solely on the glass composition.

GLASS SUMMARIES **NO. 58**

TITLE:	Materials Characterization Center, Workshop on the Irradiation Effects in Nuclear Waste Forms - Summary Report
AUTHOR:	F.P. Roberts; R.P. Turcotte; W.J. Weber
PUBLICATION:	US DOE Report, PNL-3588
DATE:	January 1, 1981
ORGANIZATION:	Pacific Northwest Laboratory, Richland, Washington
SUMMARY:	The workshop considered the utility of the proposed MCC-6 irradiation test and the effect of various types of radiation (alpha, beta, gamma, and ionizing) and transmutation effects on the waste form. Considered actinide-doping the waste form. Among the important property changes caused by irradiation are those that lead to leachability.

Waste Form:	Glass and ceramic/fuel
Waste Type:	Doping of ^{238}Pu or ^{244}Cm
Waste Loading:	--
Development Status:	Initial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Density change < 1% for saturation doses. Damage slight.
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Alpha decay is probably the principal contributor to structural damage. MCC-6 considers approximately 3×10^{18} alpha decays/cc while HLW would only receive 10^{17} to 5×10^{17}. Should consider dose equivalent to that received in one million years. Density changes for glass waste generally do not exceed 1%. Studies reported that structural changes induced by alpha decay do not adversely affect leach rates in glass waste forms. Leaching increased less than 2 times. Studies indicated that radiolysis can produce nitric acid in air-saturated water. This can affect leaching. Ceramics showed larger volume changes.

GLASS SUMMARIES

NO. 59

TITLE:	Comparative Assessment of TRU Waste Forms and Processes, Vol. I: Waste Form and Process Evaluations
AUTHOR:	W.A. Ross; R.O. Lokken; R.P. May; F.P. Roberts; C.L. Timmerman; R.L. Treat; J.H. Westik
PUBLICATION:	US DOE Report PNL-4428, Vol. I
DATE:	September 1, 1982
ORGANIZATION:	Pacific Northwest Laboratory, Richland Washington
SUMMARY:	This study provides an assessment of seven waste forms and eight processes for immobilizing TRU wastes. Includes preparation and characterization of TRU-containing waste forms. Waste forms were cast cement, cold pressed cement, FUETAP cement, borosilicate glass, aluminosilicate glass, basalt glass-ceramic, and pressed and sintered ceramic. Properties, processes, and costs were compared.

Waste Form:	Eight types noted in summary
Waste Type:	TRU waste, 3 parts sludge, 1 part incinerator ash
Waste Loading:	>20 %
Development Status:	--
Compressive Strength:	Cement 3-8; glass 35-40; ceramic 48-60 MPa. MCC-11 (Tensile)
Thermal Stability:	Glass and ceramic-no weight loss to 800°C; cement-substantial loss
Radiation Stability:	Cumulative radiation doses for time $>10^5$ yrs not significant
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	Cements produce gases due to radiation or heat
RCRA Compliance:	--

Conclusions: Cement had the lowest release of Pu, but was otherwise less durable than the glasses or ceramics. Leachate pH appeared to play an important role in the releases from the waste forms. Differences in waste forms are not more than two orders of magnitude. All seven waste forms may exceed proposed performance objectives. The maximum annual release of radionuclides should be less than 10^{-5} of the maximum inventory of that radionuclide. The cement waste forms had the lowest strength, followed by glass, then ceramics. Overall rating: ceramics, glasses, cements. All would be acceptable for WIPP or NRC requirements. Also evaluated processes.

GLASS SUMMARIES **NO. 60**

TITLE:	Environmental Assessment, Waste Form Selection for SRP High-Level Waste
AUTHOR:	Savannah River Laboratory
PUBLICATION:	U.S. Department of Energy, DOE/EA-0179
DATE:	July 1, 1982
ORGANIZATION:	Department of Energy
SUMMARY:	Discusses physical characteristics of borosilicate glass as the waste form for high-level radioactive waste and compares borosilicate glass with crystalline ceramic.

Waste Form:	Glass, borosilicate
Waste Type:	High level radioactive defense waste
Waste Loading:	28 wt%
Development Status:	Mature
Compressive Strength:	550 MPa. Fraction of fines from 10 J/cm^3 - 0.14 to 0.18% < 10μ
Thermal Stability	Will crack on cooling from melt, may increase leach by 5 times
Radiation Stability:	Performance not affected by self-irradiation for periods of 10^6 yrs
Biological Stability:	Inert
Leach Resistance:	Steady state at 25 to 55°C, 10^{-3} to 10^{-4} g/m^2/day
Immersion Stability:	Generally forms protective layer
Free Liquids:	No free liquids.
Chemical Durability:	Little effect between pH 5 to 9
Compositional Flexibility:	Stable/inert
Gas Generation:	Should be maintained in structure of glass
RCRA Compliance:	--
Conclusions:	Initial leach, 10^{-1} to 10^{-3} g/m^2/day, steady state 10^{-3} to 10^{-4}. Discusses influence of temperature, pH, water, etc. Discusses impact resistance. Compares borosilicate glass to Synroc-D

GLASS SUMMARIES **NO. 61**

TITLE:	Solubilities of Nickel and Cobalt Chalcogenides in a Nuclear Waste Glass
AUTHOR:	H.D. Schreiber; E.D. Sisk; C.W. Schreiber; J.K. Burns
PUBLICATION:	Ceramic Transactions, Vol.23, Nuclear Waste Management, pp. 213-222
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	Measured the solubilities of NiS, NiSe, NiTe, CoS, and CoSe in SRL Frit 131 as a function of temperature and oxygen fugacity.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	Nominal 28 wt%
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	Nickel sulfide and nickel selenide are both relatively insoluble in the glass
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The solubilities decreased with decreasing oxygen fugacity. In general, Ni_3S_2 is the least soluble of the compounds in SRL-131.

GLASS SUMMARIES **NO. 62**

TITLE:	DWPF Batch l, Waste Glass Investigations
AUTHOR:	R.F. Schumacher
PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management, G.G.Wicks, ed., pp. 453-463
DATE:	May 1, 1991
ORGANIZATION:	American Ceramic Society
SUMMARY:	Discusses the effects of variability in the DWPF feed mixture on glass properties, including solubility of sludge and copper-nickel precipitation.

Waste Form:	Glass, borosilicate
Waste Type:	High level radioactive defense waste
Waste Loading:	10 to 40 wt%
Development Status:	Mature
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	Limits on chrome, nickel, and copper
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Limited to 30 wt% sludge, copper limited to about 0.30 wt%.

GLASS SUMMARIES **NO. 63**

TITLE:	In Situ Vitrification of Buried Waste Sites
AUTHOR:	J.W. Shade; L.E. Thompson; C.H. Kindle
PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management, G.G. Wicks, ed., American Ceramic Society, Westerville, OH, pp. 633-640
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society
SUMMARY:	Discusses ISV of buried wastes. Stabilizes or volatilizes organic chemicals, stabilizes toxic elements.

Waste Form:	Glass, ISV
Waste Type:	Mixed waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Testing to date indicates that ISV is a promising remediation technology for application to buried wastes. It is capable of processing a wide variety of waste types. The resulting product has been shown to meet EPA requirements.

GLASS SUMMARIES **NO. 64**

TITLE:	Secondary Lead Smelter Slags: Minimizing Lead Release Levels
AUTHOR:	E.S. Shenkler; S. Graham; V.A. Greenhut
PUBLICATION:	Ceramic Transactions, Vol. 23, Nuclear Waste Management IV, G.G. Wicks, ed., American Ceramics Society, Westerville, Ohio, pg. 75-84
DATE:	April 29, 1991
ORGANIZATION:	American Ceramic Society
SUMMARY:	Secondary lead slags and mattes were formulated into glass compositions in order to stabilize the material with regard to the lead release levels as established by the EPA TCLP.

Waste Form:	Glass
Waste Type:	Lead waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Approximately 50 times improvement
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	An approximate 50 times improvement in leach resistance is possible. Varied percentage of network former.

GLASS SUMMARIES **NO. 65**

TITLE:	Reference Commercial High-Level Waste Glass and Canister Definition
AUTHOR:	S.C. Slate; W.A. Ross; W.L. Partain
PUBLICATION:	USDOE, PNL-3838
DATE:	September 1, 1981
ORGANIZATION:	Pacific Northwest Laboratory
SUMMARY:	Presents technical data and performance characteristics of a high-level waste glass and canister intended for use in the design of a complete waste encapsulation package suitable for disposal of a waste product which would be produced in a commercial nuclear-fuel reprocessing plant.

Waste Form:	Glass, borosilicate
Waste Type:	High level radioactive commercial waste/intermediate level liquid
Waste Loading:	31 wt%
Development Status:	Initial
Compressive Strength:	Estimated 37 to 51 MPa diametric compression; also discusses impact tests
Thermal Stability:	Below 500°C, diffusion processes very slow
Radiation Stability:	Radiation effects discounted; no change in leach 3×10^{17} d/cc
Biological Stability:	--
Leach Resistance:	2×10^{-6} to 45×10^{-6} g/cm^2 day Cs release (simulated and radioactive)
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	Very slow diffusion release of helium
RCRA Compliance:	--
Conclusions:	Laboratory research has indicated the practicality of reprocessing fuel for the efficient recovery of uranium and plutonium, along with a minimal addition of non-radioactive chemicals. The HLW composition is based on the Allied General Nuclear Services plant.

GLASS SUMMARIES **NO. 66**

TITLE:	Mineralogical, Textural and Compositional Data on the Alteration of Basaltic Glass From Kilauea, Hawaii to 300°C: Insights to the Corrosion of a Borosilicate Glass
AUTHOR:	D.K. Smith
PUBLICATION:	Material Research Society Symposium Proceedings, 212, pp. 115-121
DATE:	1991
ORGANIZATION:	Lawrence Livermore National Laboratory
SUMMARY:	Analysis of solids in palagnite layer of naturally altered basalt glass shows that smectite, chlorites, and actinolite form. Adopts dissolution/reprecipitation mechanism to describe banding of phases in layer.

Waste Form:	Basalt glass as analogue of borosilicate glass (SRL 165)
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Discusses secondary minerals found in palagonite layer. Critically compares basalt as analogue for HLW.

GLASS SUMMARIES **NO. 67**

TITLE:	Travel Report - Summary of Talk given at the SAIC OTD Thermal Working Meeting in Salt Lake City
AUTHOR:	M. E. Smith
PUBLICATION:	Savannah River Lab, WSRC-RP-91-1092
DATE:	October 30, 1991
ORGANIZATION:	Westinghouse Savannah River Co, Aiken, SC
SUMMARY:	Comparison of total costs of two waste forms, cement and glass, for the treatment of consolidated incinerator facility blow down. Vitrification can be as cost effective as cementation when the long term maintenance costs of the waste form are considered.

Waste Form:	Glass, cementitious
Waste Type:	Incinerator blow-down
Waste Loading:	--
Development Status:	Conceptual
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The treatment of low level waste by mixing with cement has, in the past, been considered more cost effective than the vitrification process. Vitrification can be as cost effective as cementation for this particular case.

GLASS SUMMARIES **NO. 68**

TITLE:	Impact Testing of Vitreous Simulated High-Level Waste in Canisters
AUTHOR:	T.H. Smith; W.A. Ross
PUBLICATION:	USDOE BNWL-1903
DATE:	May 1, 1975
ORGANIZATION:	Battelle, Pacific Northwest Laboratories
SUMMARY:	A portion of a risk analysis for accidental release of radioisotopes. Investigated the impact breakup characteristics of encapsulated waste glass. Tests were of a simulated waste glass in cylindrical 304L stainless steel canisters. Ten cylinders impacted at velocities of 25 and 44 fps. Twenty two smaller specimens were tested at velocities of 25, 44, 66 and 117 fps. Tested some of small canisters at 800°F.

Waste Form:	--
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Canisters breached only at the two highest velocities 66 and 117 fps. Breaches were all very small cracks. The inventory fraction smaller than 10 micron typically ranged from 10^{-8} to 10^{-4} for the 80 mph impact. The surface area typically increased by only a few percent of the initial surface area, but by a factor of 40 for the 117 fps impact (80 mph).

GLASS SUMMARIES **NO. 69**

TITLE:	Optimization of Glass Composition for the Vitrification of Nuclear Waste
AUTHOR:	P.D. Soper; D.D. Walker; M.J. Plodinec; G.J. Roberts; L.F. Lightner
PUBLICATION:	American Ceramic Society Bulletin, Vol. 62, No. 9, pp. 1013-1028, DP-MS-81-108
DATE:	September 1, 1983
ORGANIZATION:	American Ceramic Society, Westerville, Ohio
SUMMARY:	Development of the early DWPF sludge only glass frits, (Types 131-166) Twenty-five trials leading to optimization of Frit 165, basis for selection of composition. A statistical approach to glass development.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense
Waste Loading:	Nominal 28 wt%
Development Status:	Early
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	0.125 to 0.586 $g/m^2/day$
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Leach Test: Static 90°C- -40/+60 mesh, pH buffer solution, 4,7,10

S.A. 0.007 ($g/m^2/day$)	Frit 131	Frit 165
pH 4.00	0.586	0.165
pH 7.00	0.161	0.125
pH 10.00	0.458	0.477

GLASS SUMMARIES **NO. 70**

TITLE:	An Experimental Comparison of Alternative Solid Forms for Savannah River High-Level Wastes
AUTHOR:	J.A. Stone
PUBLICATION:	Scientific Basis for Nuclear Waste Management, Annual Meeting of the Material Research Society, DP-MS-81-102
DATE:	November 16, 1981
ORGANIZATION:	Material Research Society, 4th International Symposium, Scientific Basis for Nuclear Waste Management
SUMMARY:	Compares leachability of alternative waste forms: borosilicate glass, high silica glass, tailored ceramic, and Synroc-D ceramic. Uranium SR<TC<BS<HS Cesium HS<BS<SR

Waste Form:	Borosilicate and high silica glass, tailored and Synroc-D ceramic
Waste Type:	High level radioactive defense waste
Waste Loading:	Glasses ~28 wt%; ceramics ~59 wt%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Irradiated samples
Biological Stability:	--
Leach Resistance:	MCC-1 28 day @ 90°C, deionized water, silicate water, brine
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	No single waste form had a clear advantage for leach resistance. Ceramic retained U best , while high silica retained Cs best. Risk analyses indicated that all the forms tested should be satisfactory.

GLASS SUMMARIES **NO. 71**

TITLE: Comparison of Properties of Borosilicate Glass and Crystalline Ceramic Forms for Immobilization of Savannah River Plant Waste

AUTHOR: J.A. Stone; J.S. Allender; T.H. Gould

PUBLICATION: USDOE Savannah River Laboratory, DP-1627

DATE: April 1, 1982

ORGANIZATION: E.I. DuPont, SRL, Aiken, SC

SUMMARY: Properties of borosilicate glass are compared to the crystalline ceramic Synroc-D for immobilization of SRP defense high-level waste.

Waste Form: Glass, borosilicate
Waste Type: Simulated high level radioactive defense waste
Waste Loading: Nominal 28 wt% (Synroc-D ~50%)
Development Status: Early evaluation
Compressive Strength: 550 MPa (Synroc-D 280 MPa)
Thermal Stability: Both forms may fracture on cooling; little change < 500°C
Radiation Stability: Little change due to self-irradiation for periods of 1 million yrs. (m)
Biological Stability: --
Leach Resistance: MCC-1, similar to Synroc-D, $g/m^2/day$; Cs~1,Sr<10^{-3},U~0.10
Immersion Stability: --
Free Liquids: None
Chemical Durability: --
Compositional Flexibility: Change in glass structure due to irradiation is slight
Gas Generation: Little release of helium
RCRA Compliance: --
Conclusions:

	B.S. Glass	Synroc-D
Waste Loading	28 wt%	-50 wt%
Leach Rate $g/m^2/day$	Cs~1	~1
	Sr <.001	~0.1
	U -0.1	~0.0001

GLASS SUMMARIES **NO. 72**

TITLE:	Chemical Engineering Problems of Radioactive Waste Fixation by Vitrification
AUTHOR:	R.F. Taylor
PUBLICATION:	Chemical Engineering Science, Vol. 40, No.4, pp. 541-569
DATE:	1985
ORGANIZATION:	U.K. Atomic Energy Authority
SUMMARY:	A review of the chemical engineering problems faced in the vitrification of high-level radioactive liquid wastes resulting from the reprocessing of nuclear fuel. A general chemical engineering view of waste vitrification.

Waste Form:	Glass and glass-ceramic
Waste Type:	High level radioactive liquid waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Self-irradiation does not reduce mechanical properties.
Biological Stability:	--
Leach Resistance:	< 1 g/m^2/day
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	Volatility of Ru and Cs during melting
RCRA Compliance:	--
Conclusions:	Detailed discussion of volatility of Ru and Cs problems. Describes in-can melting, pot melting, continuous metallic melters, and joule heated melters. Concluded that vitrification processes have developed to the stage where a route may reasonably be chosen. Discussed the problems which are central to the vitrification process.

GLASS SUMMARIES **NO. 73**

TITLE:	The Long-Term Corrosion and Modelling of Two Simulated Belgian Reference High-Level Waste Glasses
AUTHOR:	P. Van Iseghem; B. Grambow
PUBLICATION:	Material Research Society Symposium Proceedings, 112, pp. 631-639.
DATE:	January 1, 1988
ORGANIZATION:	SCK/CEN Belgium and H-MI, Berlin
SUMMARY:	Comparison of leach test results to computer modelling for two glass compositions shows effects of SAN to reaccelerate corrosion at long times probably due to formation of secondary phases, such as analcime.

Waste Form:	Borosilicate glass
Waste Type:	Reprocessed high level waste
Waste Loading:	None
Development Status:	Intermediate
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Long-term rates around 5 x 10^{-3} and 3 x 10^{-3} $g/m^2/d$ prior to reacceleration
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

GLASS SUMMARIES **NO. 74**

TITLE: Key Parameters of Glass Dissolution in Integrated Systems

AUTHOR: E.Y. Vernaz; N. Gordon

PUBLICATION: Material Research Society Symposium Proceedings, 212, pp. 19-30

DATE: January 1, 1991

ORGANIZATION: CEA/CEN Valrho, France

SUMMARY: Summarizes test results of RFTF glass under potential French storage conditions

Waste Form:	Borosilicate glass
Waste Type:	Simulated
Waste Loading:	None
Development Status:	Advanced
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Glasses doped with Am showed no difference in leachability
Biological Stability:	--
Leach Resistance:	Long term (3 yr) leach rate= 2×10^{-3} g/m^2/day.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Presence of clay leads to higher long-term leach rates, bentonite has no effect on leaching.

GLASS SUMMARIES **NO. 75**

TITLE: Chemical Approach to Glass

AUTHOR: M.B. Volf

PUBLICATION: Book, Glass Science and Technology, 7 Elsevier, New York

DATE: January 1, 1984

ORGANIZATION:

SUMMARY: Discusses the influence of the various elements present in glass. The book is generally limited to silicate glasses, which are most widely used in commercial glassmaking. Borate, phosphate, and germanate glasses are dealt with only briefly.

Waste Form:	Glass general
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Used to discuss solubility of chlorides, noble metals, etc., in glass.

GLASS SUMMARIES **NO. 76**

TITLE:	Materials Characterization Center, Second Workshop on Irradiation Effects In Nuclear Waste Forms, Summary Report
AUTHOR:	W.J. Weber; R.P. Turcotte
PUBLICATION:	USDOE, PNL-4121
DATE:	January 1, 1982
ORGANIZATION:	Pacific Northwest Laboratory, Battelle
SUMMARY:	Discusses results of the second workshop on irradiation effects in nuclear waste forms. See Ref. No. 58.

Waste Form:	--
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Ion or neutron irradiations are not substitutes for the actinide doping technique, as described by the MCC-6. Ion or neutron irradiations may be useful for screening tests or more fundamental studies.

GLASS SUMMARIES **NO. 77**

TITLE:	Nuclear Waste Glasses
AUTHOR:	G.G. Wicks
PUBLICATION:	Treatise on Materials Science and Technology, Vol. 26, Glass IV, pp. 57-118
DATE:	January 1, 1985
ORGANIZATION:	Savannah River Laboratory
SUMMARY:	A review of vitrification and storage of high level glass waste forms.

Waste Form:	Glass, borosilicate
Waste Type:	High-level radioactive defense wastes
Waste Loading:	5 to 40 wt%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	Increase in glass surface area was less than 10 times with increased cooling rate. The effect of radiation on glass properties is small.
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Durability improves with increased waste loading
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	Generation of helium in closed canister is about 80 psi in 10^6 years.
RCRA Compliance:	--
Conclusions:	Describes DWPF, West Valley, French AVM, and ceramic melters. Describes the performance of the waste glass form. Briefly reviews some of the facets of glass leaching. Effects of waste loading, temperature, time, and pH on leaching are considered. Mechanical properties, thermal stability, and radiation effects are considered.

GLASS SUMMARIES **NO. 78**

TITLE:	High Level Radioactive Waste - Doing Something About it
AUTHOR:	G.G. Wicks; D.F. Bickford
PUBLICATION:	DuPont Savannah River Laboratory DP-1777
DATE:	March 1, 1989
ORGANIZATION:	Savannah River Laboratory
SUMMARY:	A history of the high level waste vitrification program at Savannah River. Includes the involvement of E.I. DuPont Inc.

Waste Form:	Glass, borosilicate
Waste Type:	High level radioactive defense waste
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Discusses background of Savannah River and development of the DWPF.

GLASS SUMMARIES **NO. 79**

TITLE:	Long-Term Leaching Behavior of Simulated Savannah River Plant Waste Glass
AUTHOR:	G.G. Wicks; J.A. Stone; G.T. Chandler; S. Williams
PUBLICATION:	Savannah River Lab, DP-1728
DATE:	August 1, 1986
ORGANIZATION:	E.I. DuPont, Aiken, SC
SUMMARY:	Long-term leaching data were obtained for SRP 131 type waste glasses. Experiments were conducted for time periods of up to 4 years using MCC-1 type procedures.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated high level radioactive defense waste
Waste Loading:	35 wt%
Development Status:	Intermediate glasses
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	< 1 $g/m^2/day$
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The data obtained represent a worst case for release of radionuclides from glass matrices. Observed leach rates of less than 1 $g/m^2/d$ after about 2 to 3 months and lower at longer times. Measured species, such as Sr, after leaching for 3.5 years at 90°C are about 0.006 $g/m^2/d$ and for sodium are about 0.1 $g/m^2/d$.

GLASS SUMMARIES **NO. 80**

TITLE: Analyses of SRS Waste Glass Buried in Granite in Sweden and Salt in the United States

AUTHOR: J.P. Williams; G.G. Wicks; D.E. Clark; A.R. Lodding

PUBLICATION: Ceramic Transactions, Vol. 23, Nuclear Waste Management IV, G.G. Wicks, et al., eds., pp. 663-674

DATE: April 29, 1991

ORGANIZATION: American Ceramic Society, Westerville, Ohio

SUMMARY: The chemical durability of SRL waste glass compositions buried for up to two years in granite at Stipa and WIPP was excellent and the leach rate decreased with time. These glasses were characterized by the formation of two main surface layers. Quantitative analyses of the glass interaction zone showed that less than one micron of the glass had interacted with the environment after testing at 90°C for 2 years.

Waste Form:	Glass, borosilicate
Waste Type:	Simulated, high-level radioactive waste
Waste Loading:	28 wt%
Development Status:	Advanced
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	The chemical durability of SRL waste glass compositions buried for up to two years in granite at Stripa easily passed the leaching requirements and also improved with increasing time.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	One micron interaction after 2 years in accelerated conditions at 90°C in salt and granite repositories.

HYDRAULIC CEMENT SUMMARIES

HYDRAULIC CEMENT SUMMARIES INDEX

NO. 8	AUTHOR:	Gay, R. L.; Granther, L.F.
	TITLE:	High Strength Cementized Dried Resins
	PUBLICATION:	Waste Management '88
	DATE:	3/2-6/86
NO. 9	AUTHOR:	Gilliam, T.M.; Spence, R.D.; Evans-Brown, B.S.; Morgan, I.L.; Shoemaker, S.L.; Bostick, W.D.
	TITLE:	Performance Testing of Blast Furnace Slag for Immobilization of Technetium in Grout
	PUBLICATION:	Spectrum '88
	DATE:	9/11-15/88
NO. 10	AUTHOR:	Greenhalgh, W.O.
	TITLE:	Disposal Concepts for Waste in Underground Single-Shell Storage Tanks at the Hanford Site
	PUBLICATION:	WHC-SA-1344-FP - Presented at Waste Management '92 at Tucson, AZ
	DATE:	1/92
NO. 11	AUTHOR:	Greenhalgh, W.O.
	TITLE:	The Immobilization of Organic Liquid Wastes
	PUBLICATION:	Waste Management '86
	DATE:	3/2-6/86
NO. 12	AUTHOR:	Greenhalgh, W.O.; Cash, R. J.
	TITLE:	High-Impact Concrete for Fill in U. S. Department of Transportation Type Shipping Containers
	PUBLICATION:	Waste Management '90, Tucson, AZ
	DATE:	2/25-3/1/90
NO. 13	AUTHOR:	Greenhalgh, W.O.; Cash, R.J.; Christie, M.A.
	TITLE:	TRU Waste Immobilized in Grout
	PUBLICATION:	Waste Management '88, Vol. 2
	DATE:	2/28-3/3/88
NO. 15	AUTHOR:	Howard, C.G.
	TITLE:	Advanced Cementation Concepts - Final Report
	PUBLICATION:	
	DATE:	10/89

NO. 16	AUTHOR:	Hoyle, S.; Grutzeck, M.W.
	TITLE:	Effects of Phase Composition on the Cesium Leachability of Cement-Based Waste Forms
	PUBLICATION:	
	DATE:	1986
NO. 17	AUTHOR:	Jaouen, C.; Vigreux, B.
	TITLE:	Cement Solidification of Spent Ion Exchange Resins Produced by the Nuclear Industry
	PUBLICATION:	
	DATE:	9/88
NO. 18	AUTHOR:	Kalb, P.D.; Colombo, P.
	TITLE:	Full Scale Leaching of Commercial Reactor Waste Forms
	PUBLICATION:	BNL 35561
	DATE:	9/84
NO. 19	AUTHOR:	Kalb, P.D.; Heiser, J.H. III; Colombo, P.
	TITLE:	Encapsulation of Mixed Radioactive and Hazardous Waste Contaminated Incinerator Ash in Modified Sulfur Cement
	PUBLICATION:	BNL-45163
	DATE:	1990
NO. 20	AUTHOR:	Langton, C.A.
	TITLE:	Metal Toxicity Evaluation of Savannah River Plant Saltstone Comparison of EP and TCLP Test Results
	PUBLICATION:	Waste Management '88, Vol. 1
	DATE:	2/28-3/3/88
NO. 21	AUTHOR:	Langton, C.A.; Dukes, M.D.; Simmons, R.V.
	TITLE:	Cement-Based Waste Forms for Disposal of Savannah River Plant Low-Level Radioactive Salt Waste
	PUBLICATION:	DP-MS-83-71
	DATE:	11/14-17/83
NO. 22	AUTHOR:	Lerch, R. E.
	TITLE:	Division of Waste Management, Production and Reprocessing Programs Report for January-June 1977
	PUBLICATION:	HEDL-TME-77-74
	DATE:	7/77

NO. 23	AUTHOR:	Lerch, R. E.
	TITLE:	Division of Waste Management, Production and Reprocessing Programs Report for January-December 1976
	PUBLICATION:	HDL-TME-77-40
	DATE:	1977
NO. 24	AUTHOR:	McConnell, J.W.; Neilson, R.M.; Rogers, R.D.
	TITLE:	Testing Waste Forms Containing High Radionuclide Loadings
	PUBLICATION:	Waste Management '86
	DATE:	3/2-6/86
NO. 25	AUTHOR:	McIsaac, C.V.; Akers, D.W.; McConnell, J.W.; Morcos, N.
	TITLE:	Leach Studies on Cement-Solidified Ion Exchange Resins From Decontamination Processes at Operating Nuclear Power Stations
	PUBLICATION:	EGG-M-92090
	DATE:	
NO. 26	AUTHOR:	Rosenstiel, T.L.; Bodett, S.P.; Lange, R.G.
	TITLE:	Envirostone Gypsum Cement
	PUBLICATION:	Topical Report
	DATE:	1984
NO. 27	AUTHOR:	Rzyski, B.M.; Suarez, A.A.
	TITLE:	Setting Temperature Evolution of Nitrate Radwaste Immobilized in Ordinary Portland Cement
	PUBLICATION:	
	DATE:	9/88
NO. 28	AUTHOR:	Sams, T.L.; McDaniel, E.W.
	TITLE:	Development of a Cement-Based Grout for Immobilization of a Low-Level Waste Stream Containing Sodium Sulfate
	PUBLICATION:	Waste Management '88, Vol. 1
	DATE:	2/28-3/3/88

NO. 29	AUTHOR:	Sauda, K.; Todo, F.; Nakashima, T.; Kagawa, T.; Kuribayashi, H.
	TITLE:	Advanced Cement-Solidification Process for Spent Ion-Exchange Resins
	PUBLICATION:	Waste Management '90
	DATE:	2/25-3/1/90
NO. 30	AUTHOR:	Schuler, T.F.; Charlesworth, D.L.
	TITLE:	Solidification of Radioactive Incinerator Ash
	PUBLICATION:	Waste Management '86
	DATE:	3/2-6/86
NO. 31	AUTHOR:	Siskind, B.; Adams, J.W.; Clinton, J.H.; Piciulo, P.L.
	TITLE:	The Effect of Cure Conditions on the Stability of Cement Waste Forms After Immersion in Water
	PUBLICATION:	Waste Management '88
	DATE:	2/25-3/190
NO. 32	AUTHOR:	Stone, J.A.; d'Entremont, P.D.
	TITLE:	Measurement and Control of Cement Set Times in Waste Solidification
	PUBLICATION:	DP-1404
	DATE:	9/76
NO. 33	AUTHOR:	Tallent, O.K.; McDaniel, E.W.; Delcul, G.D.; Dodson, K.E.; Trotter, D.R.
	TITLE:	Immobilization of Technetium and Nitrate in Cement-Based Materials
	PUBLICATION:	Materials Research Society Symposium Proceedings, Vol. 112, 1988
	DATE:	1988
NO. 34	AUTHOR:	Taouen, C.; Vigreux, B.
	TITLE:	Cement Solidification of Spent Ion Exchange Resins Produced by the Nuclear Industry
	PUBLICATION:	Spectrum '88
	DATE:	9/11-15/88
NO. 35	AUTHOR:	Unger, S.L.; Telles, R.W.
	TITLE:	Surface Encapsulation Process for Managing Low-Level Radioactive Wastes
	PUBLICATION:	
	DATE:	1986

NO. 36	AUTHOR:	United States - Energy Research & Development Administration
	TITLE:	Alternatives for Managing wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle - Vol. 2
	PUBLICATION:	ERDA-76-43
	DATE:	5/76
NO. 37	AUTHOR:	Veazey, G.W.
	TITLE:	The Cement Solidification Systems at LANL (1)
	PUBLICATION:	
	DATE:	12/90
NO. 38	AUTHOR:	Veazey, G.W.
	TITLE:	The Cement Solidification Systems at LANL (2)
	PUBLICATION:	
	DATE:	12/90
NO. 39	AUTHOR:	Wallace, R.M.; Hull, H.L.; Bradley, R.F.
	TITLE:	Solid Forms for Savannah River Plant High-Level Waste
	PUBLICATION:	DP-1335
	DATE:	12/73
NO. 40	AUTHOR:	Weitzman, L.; Hamel, L.E.
	TITLE:	Evaluation of Solidification/Stabilization as a Best Demonstrated Available Technology for Contaminated Soils
	PUBLICATION:	PB89-169908
	DATE:	3/89
NO. 41	AUTHOR:	Whilhite, E.L.; Hooker, R.L.; Sturm, H.F.; Langton, C.A.; Occpihti, E.S.
	TITLE:	Saltstone Processing Startup at the Savannah River Plant
	PUBLICATION:	Spectrum '88
	DATE:	9/11-15/88
NO. 42		
	AUTHOR:	Van Beek, J.E.; Wodrich, D.D.
	TITLE:	Grout Disposal System for Hanford Site Mixed Waste
	PUBLICATION:	Waste Management '90
	DATE:	March 1990

NO. 43	AUTHOR:	Cooley, C.R.; et al.
	TITLE:	Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle
	PUBLICATION:	ERDA-76-42, Vol. 2 of 5
	DATE:	May 1976
NO. 44	AUTHOR:	Place, B.G.
	TITLE:	Treatment Technology for Transuranic Waste Streams--Cementation, Vitrification, and Incineration Testing for the treatment of Spent Ion Exchange Media
	PUBLICATION:	WHC-EP-0462
	DATE:	April 1992
NO. 45	AUTHOR:	Ganser, B.L.
	TITLE:	Cementation--A Solution for Final Disposal?
	PUBLICATION:	Waste Management '90
	DATE:	March 1990
NO. 46	AUTHOR:	McConnell, Jr., J. W.; Rogers, R.D.
	TITLE:	Results of Field Testing of Waste Forms Using Lysimeters
	PUBLICATION:	Waste Management '90
	DATE:	February 1990
NO. 47	AUTHOR:	Compiled by Lerch, R.E.
	TITLE:	Division of Waste Management, Production and Reprocessing Programs Report for January-June 1977
	PUBLICATION:	HEDL-TME 77-74
	DATE:	July 1977

HYDRAULIC CEMENT SUMMARIES **NO. 1**

TITLE:	Solidification of Hazardous and Mixed Radioactive Waste at the Idaho National Engineering Laboratory
AUTHOR:	A. M. Boehmer; M. M. Larsen
PUBLICATION:	Waste Management '86
DATE:	March 2-6, 1986
ORGANIZATION:	Idaho National Engineering Laboratory (INEL)
SUMMARY:	Testing shows toxic waste materials can be solidified using cement, cement-silicate, or Envirostone binders.

Waste Form:	Cement, cement-silicate, Envirostone
Waste Type:	Mixed waste
Waste Loading:	Up to 12,500 ppm potassium chromate can be immobilized with cement silicate
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Did testing to show toxic characteristics were done away with
Conclusions:	Has listed treatment for 54 types of mixed wastes in table form.

HYDRAULIC CEMENT SUMMARIES **NO. 2**

TITLE:	Grout-Based Waste Forms for the Solidification of Anion Exchange Resins
AUTHOR:	W.D. Bostick; et al.
PUBLICATION:	Ceramic Transactions, Vol. 23
DATE:	1991
ORGANIZATION:	Oak Ridge National Laboratory
SUMMARY:	Results on the encapsulation of beaded anion exchange resins in grout formulations are presented.

Waste Form:	Type I-II portland cement, slag, and additives
Waste Type:	Dowex SRB-OH resin beads in nitrate form containing ^{99}Tc
Waste Loading:	40 vol% of waste form
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leachability index for ^{99}Tc was 14 and for nitrate ion was >9.5
Immersion Stability:	All samples passed
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The best binder composition was 75% blast furnace slag, 10 wt% Type I-II cement and 15 wt% attapulgite clay. This formula had a high leachability index for nitrate and pertechnetate ions, the lowest weight loss during wetting/drying cycle testing and an acceptable freezing/thawing behavior.

HYDRAULIC CEMENT SUMMARIES **NO. 3**

TITLE:	Syncrete (A Highly Efficient Polymer Cement Embedding Matrix for Waste Processing)
AUTHOR:	S. Cohen; P. Crouzet
PUBLICATION:	Waste Management '86
DATE:	March 2-4, 1986
ORGANIZATION:	STMI (France)
SUMMARY:	Report describes characteristics and test results of Syncrete, a polymer-cement concrete.

Waste Form:	Hydraulic concrete plus a thermosetting polymer mixture
Waste Type:	--
Waste Loading:	60% for resins, 30 to 35% for sludges and concentrates
Development Status:	--
Compressive Strength:	>90 mPa
Thermal Stability:	12,000 frost/thaw cycles over 3 years resulted in weight loss of only 0.3 %.
Radiation Stability:	No apparent damage from 10^8 rad exposures.
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	Stable during water immersion to 142 days
Free Liquids:	--
Chemical Durability:	Resists attack from 10 to 20 % acid solutions for up to a year. Also, it is readily aapplicable to salts such as sea salts.
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Syncrete combines the positive characteristics of hydraulic cement with the sealing characteristics of thermosetting polymer material.

HYDRAULIC CEMENT SUMMARIES **NO. 4**

TITLE:	A Comparison of Solidification Media for the Stabilization of Low-Level Radioactive Wastes
AUTHOR:	M.G. Cowgill
PUBLICATION:	BNL 52304
DATE:	October 1991
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	This report gives comparative performance characteristics for various waste forms.

Waste Form:	Variable
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 5**

TITLE:	Immobilization of IFR Salt Wastes in Mortar
AUTHOR:	D. F. Fischer; T. R. Johnson
PUBLICATION:	Spectrum '88
DATE:	September 11-15, 1988
ORGANIZATION:	Argonne National Laboratory
SUMMARY:	Both flyash and blast furnace slag were found to be beneficial mortar additives for immobilizing IFR waste salt.

Waste Form:	Portland cement-base mortars
Waste Type:	Alkaline earth chlorides
Waste Loading:	10%
Development Status:	--
Compressive Strength:	Required ≥7 mPa within 3 days; average 10 to 20 mPa after 3 days and 50 to 70 mPa after 56 days
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leachability indexes for chloride -7 to 8.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 6**

TITLE: Laboratory Evaluations of Mortars for Immobilizing Waste IFR Salt

AUTHOR: D. F. Fischer; et al.

PUBLICATION: ANL-IFR-120

DATE: September 1989

ORGANIZATION: Argonne National Laboratory

SUMMARY:

Waste Form:	25% Type I portland cement, 25% Class F flyash and 50% blast furnace slag
Waste Type:	Chloride salt form IFR
Waste Loading:	3-10% salt
Development Status:	More work needed for qualification
Compressive Strength:	7 day 10 mPa (1450 psig)
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leachability index greater than 7 for chloride ion
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	Yes
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	$CaCl_2$ containing salt waste produced a fluid mix that set extremely fast. Flyash addition increased set times significantly with more than 10% salt, the specimens swelled and cracked, but with about 4%, the mortar was reasonably strong and did not swell or crack. Several binder mixes were evaluated and reported.

HYDRAULIC CEMENT SUMMARIES **NO. 7**

TITLE:	Solidification by Cementation at Liquid Radioactive Primary Waste Mixes
AUTHOR:	H. J. Funk; R. Pfeiffer
PUBLICATION:	Waste Management '90
DATE:	February 25-March 1, 1990
ORGANIZATION:	Kernforschungszentrum Karlsruhe
SUMMARY:	Shows successful cementation of evaporator concentrates containing primarily sodium nitrate.

Waste Form:	Cement
Waste Type:	Liquid waste evaporator concentrates
Waste Loading:	--
Development Status:	In use
Compressive Strength:	$\geq$10 N/mm^2
Thermal Stability:	--
Radiation Stability:	3.7 Bg/cm^2
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	No free liquid detected
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 8**

TITLE:	High Strength Cementized Dried Resins
AUTHOR:	R. L. Gay; L. F. Grantham
PUBLICATION:	Waste Management '88
DATE:	1988
ORGANIZATION:	Rockwell International Corporation
SUMMARY:	Depleted ion exchange resins dried in a high-efficiency dryer and solidified in cement are nearly impermeable to water and will not reabsorb or swell when immersed.

Waste Form:	Cement
Waste Type:	Depleted ion-exchange resin
Waste Loading:	28 wt% dried resin = 70 wt% of original dewatered resins
Development Status:	Mature
Compressive Strength:	20 samples passed 0.48 mPa (69 psi) test
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	20 samples passed 90-day immersion test, 2 samples failed
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Fresh resins did not produce high-strength cement samples, but chemically spent resin waste forms passed compressive strength and immersion tests. Cost saving figures are presented for both dewatered and dried resin waste forms, based on volume reduction.

HYDRAULIC CEMENT SUMMARIES **NO. 9**

TITLE:	Performance Testing of Blast-Furnace Slag for Immobilization of Technetium in Grout
AUTHOR:	T. M. Gilliam; R. D. Spence; B. S. Evans-Brown; I. L. Morgan; S. L. Shoemaker; W. D. Bostick
PUBLICATION:	Nuclear and Hazardous Waste Management, Spectrum '88
DATE:	September 1988
ORGANIZATION:	Martin Marietta Energy Systems
SUMMARY:	Grout formulas have been developed that can satisfactorily sequester ^{99}Tc in low level mixed waste.

Waste Form:	Portland cement/flyash/blast furnace slag
Waste Type:	Heavy metals sludge and filtrate
Waste Loading:	38% weight
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leachability index for ^{99}Tc was 10.5 and NO_3 was 7.3
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Leachability indices of ^{99}Tc and NO_3 increased by 4.4 units (10.5 versus .1) and 1.4 units (7.3 versus 5.9), respectively, by the addition of slag in waste forms. The principal mechanisms of improved retention are a result of the redox potential of the slag and not the resulting improved physical properties of the grout.

HYDRAULIC CEMENT SUMMARIES **NO. 10**

TITLE:	Disposal Concepts for Waste in Underground Single-Shell Storage Tanks at the Hanford Site
AUTHOR:	W. O. Greenhalgh
PUBLICATION:	Waste Management '92
DATE:	March 1-5, 1992
ORGANIZATION:	Westinghouse Hanford Company
SUMMARY:	Disposal concepts and waste form options for use in immobilizing liquid tank waste were discussed.

Waste Form:	Variable
Waste Type:	Single-shell tank waste liquid
Waste Loading:	Variable
Development Status:	Laboratory screening of waste form candidates
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The goal of this program was to develop or establish disposal technology that could be used to remediate single-shell tank waste liquid. Disposal options to be tested were outlined.

HYDRAULIC CEMENT SUMMARIES **NO. 11**

TITLE: The Immobilization of Organic Liquid Wastes

AUTHOR: W. O. Greenhalgh

PUBLICATION: Waste Management '86

DATE: March 2-6, 1986

ORGANIZATION: Westinghouse Hanford Company

SUMMARY: The report describes the cement immobilization of low-level radioactive organic liquid waste to form a non-combustible monolith solid.

Waste Form:	Cement
Waste Type:	Organic liquid waste such as pump oil, mineral spirits, and TBP-NPH
Waste Loading:	Variable from 32 to 40 vol%
Development Status:	Applied to actual waste materials
Compressive Strength:	Variable - a 35 vol% TBP-Dodecane product exhibited a 28-day compressive strength of 250 psi.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	Flame resistant solid
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Emulsifiers and cement accelerator additives were used to solidify organic liquids up to 45% by volume. Cement products containing greater than 40 vol% might not exhibit sufficient strength to meet the NRC minimum of 60 psi without use of a good set accelerator.

HYDRAULIC CEMENT SUMMARIES **NO. 12**

TITLE:	High-Impact Concrete for Fill in U.S. Department of Transportation Type Shipping Containers
AUTHOR:	W. O. Greenhalgh; R. J. Cash
PUBLICATION:	Waste Management '90, Tucson, AZ
DATE:	February 25 - March 1, 1990
ORGANIZATION:	Westinghouse Hanford Company
SUMMARY:	The report describes a high-impact concrete product which is not brittle, but will absorb high energy impacts with little or no loss of product integrity.

Waste Form:	Cement/concrete
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	This concrete does not exhibit any appreciable compressive strength but rather absorbs the compression force. The product, without containment, can be dropped 30 ft with minimal or no loss of material.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The high impact concrete was designed for use in filling empty tanks, vessels, etc., requiring shipment over public highways with interior parts that have radioactive contamination. The fill concrete eliminates or nearly eliminates the potential loss of containment due to normal impact accidents (traffic accidents).

HYDRAULIC CEMENT SUMMARIES **NO. 13**

TITLE:	Product Characteristics of TRU Waste Immobilized in Grout
AUTHOR:	W. O. Greenhalgh; R. J. Cash; M. A. Christie
PUBLICATION:	Waste Management '88
DATE:	February 28-March 3, 1988
ORGANIZATION:	Westinghouse Hanford Company
SUMMARY:	Laboratory and drum site specimens of shred/grout (shredded waste solidified with a cement grout) will be paired and tested against NRC waste form positions and other handling and transportation type tests.

Waste Form:	Cement/grout monolith
Waste Type:	Simulated TRU combustible waste
Waste Loading:	Near 100%
Development Status:	Demonstration with simulated waste
Compressive Strength:	510 psi
Thermal Stability:	480 psi - no apparent damage
Radiation Stability:	210/120 psi - no weight loss, no apparent damage
Biological Stability:	420, 560, 690, 650, and 1010 psi - no damage
Leach Resistance:	Index >10
Immersion Stability:	>80 psi
Free Liquids:	None detected
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The shred/grout waste form produced met all DOE and NRC test requirements and exhibited the following characteristics: Free standing monolith; no free liquid; resistant to radiation; resistant to biodegradation; resistant to water leaching; stable in water; resistant to climate variations; resistant to typical fire situations; stable during cross-country transport; resistant to forklift handling punctures; stable to substantial impact-type accidents.

HYDRAULIC CEMENT SUMMARIES **NO. 14**

TITLE:	Detection of Free Liquid in Sealed Containers Simulating Drums of Solidified Radioactive Liquid Waste
AUTHOR:	W. O. Greenhalgh; C. R. Green
PUBLICATION:	Nondestructive Evaluation in the Nuclear Industry, Salt Lake City, Utah, American Society for Metals (ASM) publication
DATE:	February 11-13, 1980
ORGANIZATION:	Hanford Engineering Development Laboratory
SUMMARY:	The report describes two successfully demonstrated ways of examining drums by NDT thermal methods for water (free liquid).

Waste Form:	Cement type, urea formaldehyde, and bitumen (asphalt)
Waste Type:	Simulated sodium sulfate radwaste
Waste Loading:	Variable
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Infrared scanning camera and thermal imaging methods were shown to detect "free liquid" in sealed drums of simulated, solidified liquid waste. The volume of free liquid can also be estimated by the methods.

HYDRAULIC CEMENT SUMMARIES **NO. 15**

TITLE:	Advanced Cementation Concepts Final Report
AUTHOR:	C. G. Howard
PUBLICATION:	AEEW-R2398
DATE:	October 1989
ORGANIZATION:	Winfrith Technology Center
SUMMARY:	Improvements to existing cement formulations were sought using inorganic additives, such as microsilica and limestone flour.

Waste Form:	Ordinary portland cement/blast furnace slag/pulverized fuel ash
Waste Type:	--
Waste Loading:	45% to 52%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	The addition of microsilica reduced ^{137}Cs leachability from 45% to 145 days to 16%
Immersion Stability:	--
Free Liquids:	Samples containing 6% microsilica have no measurable bleed after 24 hours
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Microsilica and limestone flour block pore spaces in cement forms and reduced the total amount of ^{137}Cs leached out. These additives caused no detrimental effects on the dimensional stability, compressive strength, or elastic modules of the waste forms.

HYDRAULIC CEMENT SUMMARIES **NO. 16**

TITLE:	Effects of Phase Composition on the Cesium Leachability of Cement-Based Waste Forms
AUTHOR:	S. Hoyle; M. W. Grutzeck
PUBLICATION:	Waste Management '86
DATE:	1986
ORGANIZATION:	Pennsylvania State University
SUMMARY:	Phase relations in the system $CaO-Al_2O_3-SiO_2-H_2O$ were investigated to enhance Cs retention by enrichment of the bulk composition of the mixture in silica and alumina.

Waste Form:	Type I portland cement/calcium aluminate cement/condensed silica fume
Waste Type:	Deionized water containing added cesium hydroxide
Waste Loading:	30% to 60%
Development Status:	--
Compressive Strength:	15 mPa (2100 psi) to 73 mPa (10,500 psi)
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Improvement in Cs leachability is achieved by increasing silica or alumina content. A high calcium content is correlated with high Cs leachability.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	Yes
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Five mixtures having varying compositions were formulated from portland cement, calcium aluminate cement, and condensed silica fume. Leaching results indicated that the enrichment of the bulk composition of a mixture in silica and for alumina-enhanced cesium retention. All samples were found to be as strong, if not stronger, than their non-cesium containing counterparts.

HYDRAULIC CEMENT SUMMARIES **NO. 17**

TITLE:	Cement Solidification of Spent Ion Exchange Resins Produced by the Nuclear Industry
AUTHOR:	C. Jaouen; B. Vigreux
PUBLICATION:	Spectrum '88
DATE:	September 1988
ORGANIZATION:	SGN (France)
SUMMARY:	A simple rapid pretreatment.

Waste Form:	Cement
Waste Type:	Spent ion exchange resin
Waste Loading:	40 to 75 vol%, 27 wt% dry residue
Development Status:	Mature
Compressive Strength:	25 wt% resin was 9 mPa after 90 days; 10 wt% resin was 31 mPa after 90 days
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	A mobile plant has been designed utilizing a highly efficient batch mixer for mixing PWR secondary system resins and for cement solidification of ash. Pretreatment of waste can be adapted to various cases. Resins are saturated (i.e., the water content is limited), thereby reducing the water/cement/resin interactions.

HYDRAULIC CEMENT SUMMARIES **NO. 18**

TITLE:	Full Scale Leaching of Commercial Reactor Waste Forms
AUTHOR:	P. D. Kalb; P. Colombo
PUBLICATION:	BNL 35561
DATE:	September 1984
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Full-scale leaching experiment using 55-gal drum size waste forms from commercial reactor stations was accomplished

Waste Form:	Masonry cement and Type III cement
Waste Type:	Sodium sulfate and boric acid concentrated ion exchange resins
Waste Loading:	--
Development Status:	Full-scale
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Trends observed in the leaching of laboratory-scale simulated waste forms have been confirmed for full-size commercial reactor waste forms. Leachability of ^{60}Co from cement was two orders of magnitude lower than Cs isotopes. Elevated concentrations of sodium sulfate in combination with the presence of ion exchange resins can cause premature deterioration in cement waste forms.

HYDRAULIC CEMENT SUMMARIES **NO. 19**

TITLE:	Encapsulation of Mixed Radioactive and Hazardous Waste Contaminated Incinerator Ash in Modified Sulfur Cement
AUTHOR:	P. D. Kalb; J. H. Heiser III; P. Colombo
PUBLICATION:	BNL-45163
DATE:	1990
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Modified sulfur cement provides improved waste loadings and waste form performance over hydraulic cement.

Waste Form:	Sulfur cement versus hydraulic cement.
Waste Type:	LLW and mixed waste
Waste Loading:	Sulfur cement > hydraulic cement: 6 times more sodium sulfate, 2.6 times more boric acid, 1.4 times more bottom ash, and 2.7 times more flyash
Development Status:	--
Compressive Strength:	Minimum compressive strength is 1800 psi for sulfur cement containing sodium flyash, sulfate, or ash wastes
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leach Index for Co^{60} 10.7 or higher for sulfur cement and sodium sulfate or ash. Leach Index for Cs^{137} 9.7 or higher for sulfur cement and sodium sulfate or ash.
Immersion Stability:	--
Free Liquids:	--
Chemical durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 20**

TITLE:	Metal Toxicity Evaluation of Savannah River Plant Saltstone Comparison of EP and TCLP Test Results
AUTHOR:	C. A. Langton
PUBLICATION:	Waste Management '88, Vol. 1
DATE:	February 28-March 3, 1988
ORGANIZATION:	Savannah River Laboratory

SUMMARY:

Waste Form:	Saltstone grout
Waste Type:	Sodium salt solution with pH >12.5 and Cr^{+6} >100 ppm
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 21**

TITLE:	Cement-Based Waste Forms for Disposal of SRP Low-Level Salt Waste
AUTHOR:	C. A. Langton; et al.
PUBLICATION:	DP-MS-83-71
DATE:	November 1983
ORGANIZATION:	DuPont Company
SUMMARY:	A cement-based waste form, "saltstone," has been developed for SRP mixed waste containing 32 wt% sodium salts.

Waste Form:	Portland cement/flyash
Waste Type:	Salt solution containing 32 wt% sodium salts
Waste Loading:	38%
Development Status:	Mature
Compressive Strength:	3 mPa (450 psi) minimum
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	10^{-5} g/cm^2-day
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Physical properties, mineralogy and microstructure of the saltstone are similar to conventional grouts. The saltstone product, in combination with design of the total landfill, meets all state and federal guidelines for contaminant release into the environment.

HYDRAULIC CEMENT SUMMARIES **NO. 22**

TITLE:	Division of Waste Management, Production and Reprocessing Programs Report for January-June 1977
AUTHOR:	Compiled by R.E. Lerch
PUBLICATION:	HEDL-TME-77-74
DATE:	July 1977
ORGANIZATION:	Hanford Engineering Development Laboratory
SUMMARY:	This report addresses immobilization of boric acid waste and provides composition phase diagrams for boric acid and ion-exchange resin. It also presents thermal stability data for asphalt and urea-formaldehyde organic binders.

Waste Form:	Variable
Waste Type:	Low level waste and radwaste
Waste Loading:	Variable
Development Status:	--
Compressive Strength:	Data given for boric acid and ion-exchange waste forms; compression strengths up to 70 kg/cm^2 were reported.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	A variety of leach rates are tabulated, cesium leach rates varied from 0.5 to 0.01, and strontium from 0.04 to 0.00090 g/cm^2 day.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Three phase diagrams of cement/water/waste were determined for boric acid. Problems of cementing resins are discussed, some lower waste loading limits are stable. Thermal profiles on asphalt and urea-formaldehyde waste products are given. Leach rate data are provided for cesium and strontium tracers in test waste forms.

HYDRAULIC CEMENT SUMMARIES **NO. 23**

TITLE:	Division of Waste Management, Production and Reprocessing Programs Report for January-December 1976
AUTHOR:	Compiled by R.E. Lerch
PUBLICATION:	HEDL-TME-77-40
DATE:	April 1977
ORGANIZATION:	Hanford Engineering Development Laboratory

SUMMARY:

Waste Form:	Cement Type I-II
Waste Type:	Variable-calcium sulfate, neutralized ferric sulfate, sodium sulfate, sodium nitrate, sodium chloride, ion-exchange resin (anion and cation)
Waste Loading:	--
Development Status:	--
Compressive Strength:	Compressive strengths are tabulated, strengths up to 1700 psi are tested
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Three phase diagrams of cement/water/waste were determined for the simulated wastes listed above. Tables of product density and compression strengths are given.

HYDRAULIC CEMENT SUMMARIES **NO. 24**

TITLE:	Testing Waste Forms Containing High Radionuclide Loadings
AUTHOR:	J. W. McConnell, Jr.; R. M. Neilson; R. D. Rogers
PUBLICATION:	Waste Management '86
DATE:	March 2-6, 1986
ORGANIZATION:	Idaho National Engineering Laboratory
SUMMARY:	The report addresses 10 CFR 61 testing of TMI type resin waste.

Waste Form:	Portland cement and vinyl ester-styrene (VES)
Waste Type:	TMI spent resin
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	Cement: no; VES: bacteria-no, fungi-yes
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 25**

TITLE:	Leach Studies on Cement-Solidified Ion-Exchange Resins from Decontamination Processes at Operating Nuclear Power Stations
AUTHOR:	C. V. McIsaac; et al.
PUBLICATION:	EGG-M-9290
DATE:	
ORGANIZATION:	Idaho National Engineering Laboratory (INEL)
SUMMARY:	The effects of varying pH and leachant compositions on leachability were determined for cement-solidified decontamination ion-exchange resin wastes.

Waste Form:	Cement
Waste Type:	Decontamination ion-exchange resins
Waste Loading:	30%
Development Status:	Needs further evaluation to improve strength when immersed in water
Compressive Strength:	3×10^3 kPa (440 psig)
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leachability index for all test samples were >8 for Co^{60}, Ni^{63}, and Fe^{55}
Immersion Stability:	Physical disintegration during leach testing
Free Liquids:	None
Chemical Durability:	Initial leachant pH does not affect leachate pH
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Loss of waste form stability after exposure to leachants due to swelling of solidified resin beads. However, cumulative releases of radionuclides and chelating agents for forms that disintegrated were similar to those for forms that maintained their general physical integrity.

HYDRAULIC CEMENT SUMMARIES **NO. 26**

TITLE: Envirostone Gypsum Cement

AUTHOR: T. L. Rosenstiel; S. P. Bodett; R. G. Lange

PUBLICATION: Topical Report

DATE: 1984

ORGANIZATION: United State Gypsum

SUMMARY: Summary of the qualification of Envirostone gypsum cement to 10 CFR 61 type tests

Waste Form: --
Waste Type: --
Waste Loading: --
Development Status: --
Compressive Strength: --
Thermal Stability: --
Radiation Stability: --
Biological Stability: --
Leach Resistance: --
Immersion Stability: --
Free Liquids: --
Chemical Durability: --
Compositional Flexibility: --
Gas Generation: --
RCRA Compliance: --
Conclusions: Meets NRC regulatory requirements in 10 CFR 61 for the following wastes: 24% boric acid solution; mixed bed ion exchange bead resin (unexpended); powdered ion exchange resin (unexpended); lubricating oil; mixtures of oil and 24% boric acid solution; mixtures of mixed bed ion exchange bead resin and 24% boric acid solution; mixtures of powdered ion exchange resin and 24% boric acid solution; EDTA decontamination fluid; a neat aqueous mixture of ENVIROSTONE® gypsum cement to simulate encapsulation of solid objects such as used equipment, spent filter cartridges, etc.

HYDRAULIC CEMENT SUMMARIES **NO. 27**

TITLE: Setting Temperature Evolution of Nitrate Radwaste Immobilized in Ordinary Portland Cement

AUTHOR: B.M. Rzyski; A.A. Suarez

PUBLICATION:

DATE: September 1988

ORGANIZATION: IPEN-CNEN/SP

SUMMARY:

Waste Form:	Portland cement
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 28**

TITLE:	Development of a Cement-Based Grout for Immobilization of a Low-Level Waste Stream Containing Sodium Sulfate
AUTHOR:	T. L. Sams; E. W. McDaniel
PUBLICATION:	Waste Management '88, Vol. 1
DATE:	February 1988
ORGANIZATION:	Oak Ridge National Laboratory
SUMMARY:	A unique approach to grout formulation using statistical methods has been presented using a low level waste stream containing sodium sulfate

Waste Form:	Cement-based grout
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	This formulation development work encompassed several variables. the reference grout formula developed is cement 46.0%, flyash 32.8%, attapugite clay 1.4%, IRPC 0.8%. This should produce grouts that are processible and durable

HYDRAULIC CEMENT SUMMARIES **NO. 29**

TITLE:	Advanced Cement-Solidification Process for Spent Ion-Exchange Resins
AUTHOR:	K. Sauda; et al.
PUBLICATION:	Waste Management '90, Vol. 2
DATE:	February 1990
ORGANIZATION:	JGC Corporation
SUMMARY:	A new pretreatment technique for spent ion exchange resins solidified in cement has been reported.

Waste Form:	Portland cement
Waste Type:	Ion exchange resins
Waste Loading:	Resins/water/cement = 18/36/46
Development Status:	Pilot plant demonstration
Compressive Strength:	Passed, 1400 to 3000 psi
Thermal Stability:	Passed, after 30 cycles compressive strength was 1200-2000 psi
Radiation Stability:	Passed, after 10^8 rad compressive strength was 1080 psi
Biological Stability:	Passed, no growth and compressive strength was 1500 psi
Leach Resistance:	Leachability index was greater than 7
Immersion Stability:	Passed, compressive strength after 90 days ranged from 330 to 2650 psi
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	None
RCRA Compliance:	--
Conclusions:	Dewatered spent ion-exchange resins are agitated at high speed in a highly alkaline cement slurry. The pretreatment parameters have been optimized and 10 CFR 61 tests performed. The products met the waste form criteria.

HYDRAULIC CEMENT SUMMARIES **NO. 30**

TITLE:	Solidification of Radioactive Incinerator Ash
AUTHOR:	T. F. Schuler; D. L. Charlesworth
PUBLICATION:	Waste Management '86
DATE:	March 2-6, 1986
ORGANIZATION:	Savannah River Laboratory
SUMMARY:	An ash cementing process termed "Ashcrete" was set up, the waste product tested, and results reported in this paper.

Waste Form:	Cement
Waste Type:	Incinerator ash
Waste Loading:	--
Development Status:	--
Compressive Strength:	A minimum of 100 psi criteria was established, ≥1000 psi was achieved.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 31**

TITLE:	The Effect of Cure Conditions on the Stability of Cement Waste Forms After Immersion in Water
AUTHOR:	B. Siskind; J. W. Adams; J. H. Clinton; P. L. Piciulo
PUBLICATION:	Waste Management '88
DATE:	February 25-March 1, 1990
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Cement-solidified ion exchange resin exhibits a non-portland cement-like behavior if the waste loading is too high.

Waste Form:	Cement
Waste Type:	Spent mixed-bed ion exchange resin
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 32**

TITLE:	Measurement and Control of Cement Set Times in Waste Solidification
AUTHOR:	J. A. Stone; P. D. d'Entremont
PUBLICATION:	DP-1404
DATE:	September 1976
ORGANIZATION:	Savannah River Laboratory
SUMMARY:	A commercial retarder was added to cement-sludge formulations to achieve set times that are workable for routine handling equipment. Set times and compressive strengths were measured.

Waste Form:	Cement and/or concrete
Waste Type:	Simulated or actual sludge waste
Waste Loading:	10, 25, 40% of solids
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	<u>For High Alumina Cement</u> Tank 5: 9,500 psi at 10% sludge, 9,000 psi at 25%, and 3,000 psi at 40% Tank 13: 900 psi at 10% sludge, 7,000 psi at 25%, and 1,600 psi at 40% Tank 15: 6,800 psi at 10% sludge, 4,800 psi at 25%, and 1,400 psi at 40%

HYDRAULIC CEMENT SUMMARIES **NO. 33**

TITLE: Immobilization of Technetium and Nitrate in Cement-Based Materials

AUTHOR: O.I. Tallent; et al.

PUBLICATION:

DATE: 1988

ORGANIZATION: Martin Marietta

SUMMARY: The leachability of technetium and nitrate wastes immobilized in cement-based materials have been investigated.

Waste Form:	Blends of Type I-II cement/slag/flyash
Waste Type:	Simulated double shell slurry feed from Hanford
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leachability index for nitrate ranged from 7.0 to 7.5 and for technetium from 8.0 to 8.3
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Decreasing waste concentration by dilution with water decreased leachability to Tc ion, but did not affect nitrate ion leachability. Chemical reducing properties of the slag reduce the Tc from the pertechnetate to the dioxide, a less soluble and slower leaching species.

HYDRAULIC CEMENT SUMMARIES **NO. 34**

TITLE:	Cement Solidification of Spent Ion Exchange Resins Produced by the Nuclear Industry
AUTHOR:	C. Taouen; B. Vigreux
PUBLICATION:	Spectrum '88
DATE:	September 11-15, 1988
ORGANIZATION:	SGN (France)
SUMMARY:	A mobile cementation solidification was designed to treat the resin waste.

Waste Form:	Cement solidification
Waste Type:	Spent ion exchange resin
Waste Loading:	40 to 75%
Development Status:	The SGN resin measured 8 mPa after 28 days and 9 mPa after 90 days.
Compressive Strength:	10% resin measured 26 mPa after 28 days and 31 mPa after 90 days.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 35**

TITLE:	Surface Encapsulation Process for Managing Low-Level Radioactive Wastes
AUTHOR:	S. L. Unger; R. W. Telles
PUBLICATION:	
DATE:	1986
ORGANIZATION:	Environmental Protection Polymers, Inc.

SUMMARY:

Waste Form:	Surface encapsulated agglomerated modules - agglomerates of mixed LLRW with co-reacted polyethylene and polybutadiene
Waste Type:	Low level radioactive waste
Waste Loading:	50% of total (including jacket)
Development Status:	Prototype in development
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 36**

TITLE:	Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle - Vol. 2
AUTHOR:	United States - Energy Research & Development Administration
PUBLICATION:	ERDA-76-43
DATE:	May 1976
ORGANIZATION:	United States - Energy Research & Development Administration
SUMMARY:	Volume 2 addresses solidification methods and waste forms including comparisons.

Waste Form:	--
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 37**

TITLE: The Cement Solidification Systems at LANL (1)

AUTHOR: G. W. Veazey

PUBLICATION:

DATE: December 1990

ORGANIZATION: Los Alamos National Laboratory

SUMMARY: 7A-50 infrequently used system.

Waste Form:	Portland cement
Waste Type:	TA-50 system pH-adjusted TRU-waste
Waste Loading:	42% waste
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	Some surface moisture
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Corrosion of drum can occur if moisture gains entrance into drum. Entrance may be made through carbon filters on drum vents if not protected from environment.

HYDRAULIC CEMENT SUMMARIES **NO. 38**

TITLE:	The Cement Solidification Systems at LANL (2)
AUTHOR:	G. W. Veazey
PUBLICATION:	LA-UR-90-4161
DATE:	December 1990
ORGANIZATION:	Los Alamos National Laboratory
SUMMARY:	Problems of drum corrosion in extended outdoor storage prior to burial and appearance of free liquid in sealed drums are addressed.

Waste Form:	Portland cement and Envirostone
Waste Type:	Evaporator bottoms TRU-level waste
Waste Loading:	23 gal sludge per 55-gal drum
Development Status:	Existing operating system
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Appearance of free liquid possibly linked to gamma irradiation
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	Appearance of more than 15 liters low-level free liquid in sealed drums after 8-44 weeks.
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Theories have been proposed for the appearance of free liquids, although the exact causes have not been pinpointed. Inadequate mixing, gamma irradiation, and exposure of drums to rain are likely causes.

HYDRAULIC CEMENT SUMMARIES **NO. 39**

TITLE:	Solid Forms for Savannah River Plant High-Level Waste
AUTHOR:	R. M. Wallace; H. L. Hull; R. F. Bradley
PUBLICATION:	DP-1335
DATE:	December 1973
ORGANIZATION:	Savannah River Laboratory
SUMMARY:	This study was made to evaluate candidate solid waste forms and solidification processes.

Waste Form:	--
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 40**

TITLE:	Evaluation of Solidification/Stabilization As a Best Demonstrated Available Technology for Contaminated Soils
AUTHOR:	L. Weitzman; L. E. Hamel
PUBLICATION:	PB89-169908
DATE:	March 1989
ORGANIZATION:	Acurex Corporation
SUMMARY:	Demonstrated that soil could be immobilized and contents stabilized by use of cement, lime, or a lime flyash mixture.

Waste Form:	Portland cement, lime kiln dust, equal parts of lime and flyash
Waste Type:	Hazardous contaminated soil
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

HYDRAULIC CEMENT SUMMARIES **NO. 41**

TITLE:	Saltstone Processing Startup at the Savannah River Plant
AUTHOR:	E. L. Whilhite; R. L. Hooker; H. F. Sturm; C. A. Langton; E. S. Occpihti
PUBLICATION:	Spectrum '88
DATE:	September 11-15, 1988
ORGANIZATION:	E. I. DuPont de Nemours and Company
SUMMARY:	Saltstone was shown to be non-hazardous after EP and TCLP testing. The feed is hazardous because of Cr and other metals.

Waste Form:	Saltstone grout
Waste Type:	Tank waste (LLW)
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Diffusion Coefficients: 1.3×10^{-9} cm^2/sec for nitrate; 4×10^{-12} cm^2/sec for technetium; 4×10^{-13} cm^2/sec for chromium.

HYDRAULIC CEMENT SUMMARIES **NO. 42**

TITLE:	Grout Disposal System for Hanford Site Mixed Waste
AUTHOR:	J. E. Van Beek; D. D. Wodrich
PUBLICATION:	Waste Management '90, pp 797-802
DATE:	March 1990
ORGANIZATION:	Westinghouse Hanford Company
SUMMARY:	The Grout Treatment Facility has been constructed at Hanford for processing liquid radioactive and hazardous tank wastes into a cement-based solid for disposal in near-surface concrete vaults.

Waste Form:	Grout
Waste Type:	Phosphate/Sulfate salt solution
Waste Loading:	--
Development Status:	Large-scale disposal has been performed
Compressive Strength:	200 to 2000 psi
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Leach index of Cs-137 is 9 and of Sr-90 is 14
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The grouting process combines cementitious materials with liquid waste to form grout slurry which is pumped to large, underground concrete vaults for solidification and final disposal. The Grout Treatment Facility disposal system design is a unique concept for meeting both hazardous and low-level waste disposal criteria.

HYDRAULIC CEMENT SUMMARIES **NO. 43**

TITLE: Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle

AUTHOR: C. R. Cooley, et al.

PUBLICATION: ERDA-76-42, Vol. 2 of 5

DATE: May 1976

ORGANIZATION: US ERDA

SUMMARY:

Waste Form:	Portland cement, bitumen, UF
Waste Type:	Na_2SO_4, boric acid, bead resins, diatomaceous earth
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	10^{-5} to 10^{-1} gm/Cm^2 day for sodium ion and 10^{-9} to 10^{-7} gm/Cm^2 day for actinides
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Typical waste/cement formulations have been presented. Solutes in waste solutions and slurries can be incorporated in cement products at salt/cement weight ratios of 0.5, although more typically from 0.15 to 0.3. The maximum water to cement weight ratio is 0.5 and the minimum is 0.25. Sodium silicate as an additive helps to lower final volume increase factor.

HYDRAULIC CEMENT SUMMARIES **NO. 44**

TITLE:	Treatment Technology for Transuranic Waste Streams--Cementation, Vitrification, and Incineration Testing for the treatment of Spent Ion Exchange Media
AUTHOR:	B. G. Place
PUBLICATION:	WHC-EP-0462
DATE:	April 1992
ORGANIZATION:	Westinghouse Hanford Company
SUMMARY:	Cementation pretreatment testing was conducted for ion exchange resins and zeolites from a number of Hanford Site facilities.

Waste Form:	1. Cement 2. Glass
Waste Type:	Organic ion exchange resins and zeolites
Waste Loading:	--
Development Status:	--
Compressive Strength:	920-3700 psi
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Attritive and size-reduction pretreatment methods proved most effective in producing a stable final waste form. Pretreated zeolite exhibited substantially higher compressive strengths and higher waste packaging efficiencies when compared to untreated zeolite.

HYDRAULIC CEMENT SUMMARIES **NO. 45**

TITLE: Cementation--A Solution for Final Disposal?

AUTHOR: B. L. Ganser

PUBLICATION: Waste Management '90

DATE: March 1990

ORGANIZATION: NUKEM Gmb H

SUMMARY: The suitability of cemented waste forms for final disposal in Germany has been evaluated through several tests from 1979 to 1989.

Waste Form:	Cement and additives
Waste Type:	Evaporator concentrates, resins, filter sludges
Waste Loading:	Up to 40 wt% waste content (dry substance)
Development Status:	--
Compressive Strength:	10-100 MPa
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	10^{-4} to $7x10^{-3}$ gm/cm^2 day
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Blast furnace slag cement gave lower average leach rates than ordinary Portland cement. Long term leach tests showed that after about 5 years there was a sharp decrease in leach rates. Direct cementation of liquid wastes showed excellent mechanical properties.

HYDRAULIC CEMENT SUMMARIES **NO. 46**

TITLE:	Results of Field Testing of Waste Forms Using Lysimeters
AUTHOR:	J. W. McConnell, Jr.; R. D. Rogers
PUBLICATION:	Waste Management '90
DATE:	February 1990
ORGANIZATION:	Idaho National Engineering Laboratory
SUMMARY:	Results of lysimeter tests on ion-exchange resins are presented and the use of lysimeter data in performance assessment is discussed.

Waste Form:	Portland Type I-II
Waste Type:	Ion-exchange resins from prefilters
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Sr-90 is more prevalent than Cs-137, CO-60 or Sb-1215 in collected liquid samples. The limiting step in receiving Sr-90 in the leachate is not release of the nuclide from the waste forms, but rather it is the soil characteristics that limit movement.

HYDRAULIC CEMENT SUMMARIES **NO. 47**

TITLE:	Division of Waste Management, Production and Reprocessing Programs Report for January-June 1977
AUTHOR:	Compiled by R. E. Lerch
PUBLICATION:	HEDL-TME 77-74
DATE:	July 1977
ORGANIZATION:	Hanford Engineering Development Laboratory
SUMMARY:	The report addresses immobilization of boric acid waste and provides composition phase diagrams for boric acid and ion-exchange resin. It also presents thermal stability data for asphalt and urea-formaldehyde organic binders.

Waste Form:	Variable
Waste Type:	Low-level waste and radwaste
Waste Loading:	Variable
Development Status:	--
Compressive Strength:	Data given for boric acid and ion-exchange waste forms; compression strengths up to 70 kg/cm^2 were reported.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Three-phase diagrams of cement/water/waste were determined for boric acid. Problems of cementing resins are discussed, some lower waste loading limits are stable. Thermal profiles on asphalt and urea-formaldehyde waste products are given. Leach rate data is provided for cesium and strontium tracers in test waste forms.

SULFUR POLYMER CEMENT SUMMARIES

SULFUR POLYMER CEMENT SUMMARIES INDEX

NO. 1	AUTHOR:	Darnell, G.R.; Aldrich, W.C; Logan, J.A.
	TITLE:	Full-Scale Tests of Sulfur Polymer Cement and Nonradioactive Waste in Heated and Unheated Prototypical Containers
	PUBLICATION:	EGG-WM-10109, Idaho National Engineering Laboratory
	DATE:	1992
NO. 2	AUTHOR:	Johnson, E.R.
	TITLE:	An Assessment of the Potential of Modified Sulfur Cement for the Conditioning of Low-Level Radioactive Waste for Dumping at Sea
	PUBLICATION:	JAI-200
	DATE:	6/83
NO. 3	AUTHOR:	van Dalen, A.; Rijpkema, J.E.
	TITLE:	Modified Sulphur Cement: A Low Porosity Encapsulation Material for Low, Medium, and Alpha Waste
	PUBLICATION:	Nuclear Science and Technology (Commission of the European Communities), EUR 12303
	DATE:	1989
NO. 4	AUTHOR:	Kalb, P.D.; Heiser III, J.H.; Colombo, P.
	TITLE:	Modified Sulfur Cement Encapsulation of Mixed Waste Contaminated Incinerator Fly Ash
	PUBLICATION:	Waste Management, Vol. II, pp. 147-153
	DATE:	1991
NO. 5	AUTHOR:	Darnell, G.R.
	TITLE:	Sulfur Polymer Cement, a Solidification and Stabilization Agent for Hazardous and Radioactive Wastes
	PUBLICATION:	First International Mixed Waste Symposium, Washington, D.C.,
	DATE:	1991
NO. 6	AUTHOR:	Kalb, P.D.; Heiser III, J.H.; Pietrzak, R.; Colombo, P.
	TITLE:	Durability of Incinerator Ash Waste Encapsulated in Modified Sulfur Cement
	PUBLICATION:	BNL-45292, 1991 Incineration Conference, Knoxville, TN
	DATE:	1991

NO. 7	AUTHOR:	Kalb, P.D.; Heiser III, J.H.; Pietrzak, R.; Colombo, P.
	TITLE:	Comparison of Modified Sulfur Cement and Hydraulic Cement for Encapsulation of Radioactive and Mixed Wastes
	PUBLICATION:	Twelfth Annual U.S. DOE Low-Level Waste Management Conference
	DATE:	1991
NO. 8	AUTHOR:	Kalb, P.D.; Heiser III, J.H.; Colombo, P.
	TITLE:	Encapsulation of Mixed Radioactive and Hazardous Waste Contaminated Incinerator Ash in Modified Sulfur Cement, BNL-43691
	PUBLICATION:	Incineration Conference 1990, San Diego, CA,
	DATE:	1991
NO. 9	AUTHOR:	McBee, W.C.; Sullivan, T.A.; Fike, H.L.
	TITLE:	Sulfur Construction Materials
	PUBLICATION:	United States Department of the Interior Bureau of Mines Bulletin 678
	DATE:	1985

SULFUR POLYMER CEMENT SUMMARIES **NO. 1**

TITLE:	Full-Scale Tests of Sulfur Polymer Cement and Nonradioactive Waste in Heated and Unheated Prototypical Containers
AUTHORS:	G.R. Darnell; W.C. Aldrich; J.A. Logan
PUBLICATION:	EGG-WM-10109, Idaho National Engineering Laboratory
DATE:	1992
ORGANIZATION:	EG&G Idaho, Inc.

SUMMARY: Describes and discusses the first full-scale tests of SPC as a stabilization agent for simulated radioactive incinerator ash and steel waste. Tests were conducted with a horizontal, externally-and-internally heated, production-scale mixer. A prototypical, rectangular, 24-ft^3, thin-walled, steel waste container with no appendages was used to hold 800 lb of simulated sized waste while molten SPC combined with incinerator hearth ash under 3/8-in. diameter was poured into it. One test was with an ambient-temperature container and steel waste. Another test was with the steel waste, the container, and the mold-form preheated to melt temperature in an oven. Destructive examination showed better results in the concrete mass where heating was applied. It was proposed that better heating of the container and waste be provided for the next tests.

Waste Form:	Sulfur polymer cement
Waste Type:	Incinerator hearth ash and steel pipes (nonradioactive)
Waste Loading:	40 wt% ash (not counting 800 lb of steel pipe)
Development Status:	50% established
Compressive Strength:	Lab tests not conducted, but resisted hammer blows
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Stability:	--
Gas Generation:	--
RCRA Compliance:	--

Conclusions: Preheating the waste container and its 800 lb of steel "waste" to 135°C greatly improved the pour and eliminated nearly all voids experienced in the "cold test," even though the container and contents lost ~34°C during the pour. The evidence indicates that the container and its contents need to be preheated and then maintained at SPC melt temperatures throughout the pour.

SULFUR POLYMER CEMENT SUMMARIES **NO. 2**

TITLE:	An Assessment of the Potential of Modified Sulfur Cement for the Conditioning of Low-Level Radioactive Waste for Dumping at Sea
AUTHORS:	E.R. Johnson
PUBLICATION:	JAI-200
DATE:	June 1983
ORGANIZATION:	E. R. Johnson Associates, Inc. for Brookhaven National Laboratory
SUMMARY:	This report presents curves on strength versus time, strength growth curve of SPC versus Portland cement concrete, stress strain, modulus of elasticity, freeze-thaw cycles to failure for SPC and Portland cement concrete, linear thermal expansion, and variation of compressive strength and specific gravity. SPC's properties for radioactive waste stabilization include rapid curing; no residual free water; little degradation (especially from radiation); resistant to chemical and physical degradation, not chemically reactive, low leaching rate, particularly by saline waters or ground; and is easily handled and controlled by operators.

Waste Form:	Sulfur polymer cement
Waste Type:	--
Waste Loading:	--
Development Status:	Initial effort for evaluation as final waste form
Compressive Strength:	Equal to or greater than that of hydraulic concrete
Thermal Stability:	Resistant to thermal cycling
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	Relatively impervious to water and moisture
Free Liquids:	None
Chemical Durability:	Strong, corrosion resistant concrete; highly resistant to dissolution and chemical corrosion
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--

Conclusions: The author predicted the attributes of SPC as a radioactive waste stabilization agent that have since proven true. A genesis report for radioactive and hazardous waste stabilization.

SULFUR POLYMER CEMENT SUMMARIES **NO. 3**

TITLE: Modified Sulphur Cement: A Low Porosity Encapsulation Material for Low, Medium and Alpha Waste

AUTHOR: van Dalen, A., and Rijpkema, J. E.

PUBLICATION: Nuclear Science And Technology (Commission of the European Communities), EUR 12303

DATE: 1989

ORGANIZATION: Energy Research Foundation ECN, 1755 ZG Petten, The Netherlands

SUMMARY: This report summarizes tests conducted with modified sulfur cement, more commonly referred to as sulfur polymer cement (SPC). It confirms tests conducted in the U.S.A. at Brookhaven National Laboratory (BNL). They, like BNL, combined SPC with dried ion-exchange resins. In both cases the resins took on moisture very quickly and ruptured the concrete. The Netherlands tried a different approach that worked. They combined the ion-exchange resins with SPC, raised the temperature from the normal 135°C to 230 to 250°C and held that temperature for 3 hours. The test specimen was immersed in water for one year with no degradation. No information is provided on how they handled the gaseous emissions. All of the NRC's laboratory tests were conducted.

Waste Form:	Sulfur polymer cement concrete
Waste Type:	Ion-exchange resins; sludges with 5% U, 1% Ti, 3% Cu, 1% Mn, 3% Al, and 2% Na; precipitates; lead iodide (model for ^{129}I); PbI_2; incinerator ashes with borate, $CaCo_3$, CsCl, $EuCl_3$, and 1.86% K_2O, 1.04% Na_2, 2.07% Fe_2O_3, 28.38% Al_2O_3, 16.09% CaO, 2.12% MgO, 43.88% SiO_2, 1,72% TiO_2, 0.92% BaO, 0.10% MnO, and 0.32% P_2O_3; ^{137}Cs; ^{60}Co; $SrCO_3$; toxic metals; and other metals
Waste Loading:	See above
Development Status:	Second major effort in testing SPC for final waste form
Compressive Strength:	3333 psi after one day and 9275 psi after two years
Thermal Stability:	Passed tests
Radiation Stability:	6232 psi before 10^8 rad and 8840 psi after
Biological Stability:	--
Leach Resistance:	--

SULFUR POLYMER CEMENT SUMMARIES

NO. 3 (cont.)

Immersion Stability:	Passed tests
Free Liquids:	None
Chemical Durability:	No problem noted. Irradiation suggested longevity
Compositional Flexibility:	Improved by the addition of Al_2O_3 and/or Fe_2O_3
Gas Generation:	Subjecting SPC with samples containing PbI_2, incinerator ash, and borate waste to 10^8 rad produced no gaseous radiolysis products
RCRA Compliance:	Not tested to EPA's TCLP
Conclusions:	If we can reproduce their excellent results with ion-exchange resins without any safety concern, that fact alone makes this report a valuable asset.

SULFUR POLYMER CEMENT SUMMARIES **NO. 4**

TITLE:	Modified Sulfur Cement Encapsulation of Mixed Waste Contaminated Incinerator Fly Ash
AUTHORS:	P. D. Kalb; J.H. Heiser III; P. Colombo
PUBLICATION:	Waste Management, Vol. II, pp. 147-153
DATE:	1991
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Upon cooling, SPC achieves compressive strengths averaging 4,000 psi. Due to high concentrations of zinc, lead, cadmium, sodium, and chlorine in the mixed waste fly ash obtained from the Waste Experimental Reduction Facility (WERF), it is difficult to combine with portland cement. That waste also contained approximately 1.5 B/g (pc/g) of activity made up of mixed fusion products--primarily ^{137}Cs and activation products--which were primarily ^{57}Co and ^{125}Sb. Highly soluble metal chloride salts (mostly zinc chloride) further complicate this waste.

Waste Form:	Sulfur polymer cement
Waste Type:	Mixed waste fly ash (37 wt% zinc, 7.5 wt% lead, 0.2 wt% cadmium)
Waste Loading:	43 wt%
Development Status:	Early
Compressive Strength:	4,000 psi (>27.6 MPa), which is twice the binder strength alone
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	3 to 4 times better than Portland cement
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Passed TCLP with high loadings of lead and cadmium
Conclusions:	Presence of high concentrations of zinc, lead, cadmium, sodium, and chloride make loading in SPC more successful than in portland cement by a factor or 3.2..

SULFUR POLYMER CEMENT SUMMARIES

NO. 5

TITLE:	Sulfur Polymer Cement, a Solidification and Stabilization Agent for Hazardous and Radioactive Wastes
AUTHORS:	G.R. Darnell
PUBLICATION:	First International Mixed Waste Symposium, Washington, D.C.
DATE:	1991
ORGANIZATION:	EG&G Idaho, Inc., Idaho National Engineering Laboratory
SUMMARY:	SPC's resistance to acids, salts, water penetration, and physical failure are discussed. It discusses the ability to remelt stabilized waste, should some remediation decree be rendered. SPC's propensity for microencapsulation of toxic metals is discussed. SPC's ability to accept higher loadings of troublesome wastes than other agents is discussed.

Waste Form:	Sulfur polymer cement concrete
Waste Type:	MW incinerator flyash and hearthash, boric acid, sodium sulfate
Waste Loading:	43 wt% mixed waste flyash (37 wt% zinc, 7.5 wt% lead, 0.2 wt% cadmium); 40 wt% boric acid; 40 wt% sodium sulfate; 40 wt% hearthash
Development Status:	Early
Compressive Strength:	Averages ~4,000 psi
Thermal Stability:	--
Radiation Stability:	Gains compressive strength
Biological Stability:	Passed test with no visible deterioration
Leach Resistance:	4 to 8 orders of magnitude better than NRC requirements
Immersion Stability:	Passes with addition of 0.5 wt% Omens Corning glass fibers
Free Liquids:	No free liquid in final waste form
Chemical Durability:	Passed all EPA and NRC lab-scale tests
Compositional Flexibility:	Passed all EPA and NRC lab-scale tests
Gas Generation:	No gas generation during 10^8 rad test
RCRA Compliance:	--
Conclusions:	Sulfur polymer cement resists attack by most acids and salts. This and other facts suggest longevity. SPC gains strength when subjected to high radiation, which also suggests longevity. SPC can pass the EPA's TCLP with heavy loadings of toxic metals and no volatilization of toxic metals in the process.

SULFUR POLYMER CEMENT SUMMARIES **NO. 6**

TITLE:	Durability of Incinerator Ash Waste Encapsulated in Modified Sulfur Cement
AUTHORS:	P. D. Kalb, J. H. Heiser III, R. Pietrzak, and P. Colombo
PUBLICATION:	BNL-45292, 1991 Incineration Conference, Knoxville, TN
DATE:	1991
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Brookhaven National Laboratory completed durability tests with SPC laden with mixed waste fly ash. Tests completed were those prescribed by the NRC; specifically, the tests were compressive strength, biodegradation, irritation, water immersion, thermal cycling, and leaching. Incinerator hearth ash and fly ash from the rotary-kiln incinerator at Rocky Flats Plant had no problem passing the tests with a 43 wt% loading in SPC. Fly ash from the INEL's WERF were loaded at the same ratio, but the high concentrations of soluble metal salts tended to deteriorate in the immersion test. The same stabilized waste was subjected to EPA's TCLP test with successful results.

Waste Form:	Sulfur polymer cement
Waste Type:	RFP ash and INEL ash (mixed waste)
Waste Loading:	43 wt%
Development Status:	--
Compressive Strength:	4,430 psi (30.5 MPa) at maximum ash loading of 43 wt%
Thermal Stability:	No significant change in compressive strength
Radiation Stability:	Passed tests
Biological Stability:	No visible microbial growth of either bacteria or fungi
Leach Resistance:	5 to 8 orders of magnitude slower than NRC leach index
Immersion Stability:	Glass fibers required to pass with one ash tested
Free Liquids:	None
Chemical Durability:	Passed all tests
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Passed TCLP test with 43 wt% of mixed waste flyash

Conclusions: Compressive strength increased with increased waste loadings (4,430 psi at 43 wt% loading). Had to add glass 0.5 wt% fibers in the concrete to pass immersion test with one of the ashes tested (contained extremely high concentrations of soluble metal salts).

SULFUR POLYMER CEMENT SUMMARIES **NO. 7**

TITLE:	Comparison of Modified Sulfur Cement and Hydraulic Cement for Encapsulation of Radioactive and Mixed Wastes
AUTHORS:	P. D. Kalb; J. H. Heiser III; R. Pietrzak; P. Colombo
PUBLICATION:	Twelfth Annual U.S. DOE Low-Level Waste Management Conference
DATE:	1991
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Modified sulfur cement (SPC) is compared to hydraulic cements in its capabilities as radioactive and mixed waste stabilization agent. SPC is a thermoplastic that melts at 120°C and requires no activator, while hydraulic cements do require an activator. At Brookhaven National Laboratory they compared the loadings of four divergent wastes that could be stabilized in the 2 cements to EPA standards. The four wastes were loaded in SPC and hydraulic cements. SPC was capable of passing the TCLP with the following waste loadings: incinerator bottom ash, 1.4 wt%; boric acid, 2.6 wt%; incinerator fly ash, 2.7 wt%; and sodium sulfate, 6.0 wt%. The tests showed that an average of 3.2 times more waste by volume could be placed in SPC than in portland cement. It was concluded that untreated nitrate salts and ion-exchange resins could not be successfully stabilized in SPC.

Waste Form:	Sulfur polymer cement			
Waste Type:	Sodium sulfate,	fly ash,	bottom ash,	boric acid
Waste Loading:[a]	40(9)	43(16)	43(40)	40(15)
Development Status:	In earliest stages of testing and development			
Compressive Strength:[a]	4300(3000)	4200(4000)	6500(4000)	2000(1400)
Thermal Stability:[b]	4300(3700)	4200(2800)	6500(4700)	2000(2200)
Radiation Stability:	--			
Biological Stability:	--			
Leach Resistance:	4 to 8 orders of magnitude better than NRC leach index			
Immersion Stability:[c]	4300(3000)	4300(4000)	6500(4000)	2000(1400)

a. Expressed in terms of weight percent. Unbracketed is for SPC and bracketed is for portland cement.

b. Before cycling is unbracketed and after cycling is bracketed.

c. ^{60}Co is unbracketed and ^{137}Cs is bracketed.

Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Passed TCLP
Conclusions:	SPC will accommodate more waste than portland cement with higher compressive strength.

SULFUR POLYMER CEMENT SUMMARIES **NO. 8**

TITLE:	Encapsulation of Mixed Radioactive and Hazardous Waste Contaminated Incinerator Ash in Modified Sulfur Cement
AUTHORS:	P. D. Kalb; J. H. Heiser III; P. Colombo
PUBLICATION:	BNL-43691, Incineration Conference 1990, San Diego, CA
DATE:	1990
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Modified sulfur cement (SPC) was tested with mixed waste fly ash from the INEL's WERF. Wet chemical and solid phase waste characterization analyses showed high concentrations of lead and cadmium and other soluble metal salts in the fly ash. The EPA's TCLP test was passed with a 43 wt% loading of the fly ash after adding 7 wt% sodium sulfide, which enhanced the retention of the soluble metal salts. This work was completed at Brookhaven National Laboratory.

Waste Form:	Sulfur polymer cement
Waste Type:	Mixed waste fly ash containing 7.5 wt% lead and 0.2 wt% cadmium
Waste Loading:	43 wt%
Development Status:	Early stages of testing
Compressive Strength:	Exceeds 4,000 psi at 43 wt% loading
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Passed TCLP test at 43 wt% loading; well below EPA concentration criteria for delisting
Conclusions:	Addition of 7 wt% sodium sulfide allowed more of toxic-metal-bearing ash to be added and pass the TCLP test.

SULFUR POLYMER CEMENT SUMMARIES **NO. 9**

TITLE:	Sulfur Construction Materials
AUTHORS:	W.C. McBee; T.A. Sullivan; H.L. Fike
PUBLICATION:	United States Department of the Interior Bureau of Mines Bulletin 678
DATE:	1985
ORGANIZATION:	U.S. Bureau of Mines
SUMMARY:	This report on SPC takes it from prehistoric times when elemental sulfur was used as a cement through its development as a modern cement, with some exceptional qualities. Discussed in this report are SPC's strengths and weaknesses, safety considerations, chemical reactions, and effects of aggregates. Charts present curves on viscosity dependency, strength, differential scanning calorimetry thermograms, linear thermal-expansion data, aggregate gradation, stress strain, compressive strength, load deflection, moisture, freeze-thaw durability, and others. Lists are provided that define the success of SPC in various acids and salts, and the time of exposure.

Waste Form:	Sulfur polymer cement
Waste Type:	--
Waste Loading:	--
Development Status:	SPC developed 13 years earlier
Compressive Strength:	--
Thermal Stability:	Successfully resists freeze-thaw cycles
Radiation Stability:	--
Biological Stability:	No reaction
Leach Resistance:	--
Immersion Stability:	Routinely used as tanks for acid and salt solutions
Free Liquids:	None; impermeable to water
Chemical Durability:	Resists most acids and salts that destroy Portland cement
Compositional Flexibility:	Resists most acids and salts that destroy Portland cement
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	This report does not discuss encapsulation of wastes, but indirectly addresses the problem that has plagued the waste stabilization industry: concrete degradation.

CERAMIC SUMMARIES

CERAMIC SUMMARIES **NO. 1**

TITLE:	An ICPP Aluminum Phosphate Ceramic Waste Form: Synthesis and Room-Temperature Aqueous Stability
AUTHORS:	Paul Silva; Barry E. Scheetz
PUBLICATION:	Advances in Ceramics 8, American Ceramic Society, 1984
DATE:	1974
ORGANIZATION:	Pennsylvania State University
SUMMARY:	Describes the synthesis and dissolution behavior of a berlinite-based ($AlPO_4$) ceramic encapsulant for the high-alumina nuclear waste at the Idaho Chemical Processing Plant (ICPP).

Waste Form:	Aluminum phosphate (berlinite) low-temperature ceramic
Waste Type:	High-alumina nuclear waste at the Idaho Chemical Processing Plant (ICPP)
Waste Loading:	42% (Simulated ICPP alumina waste)
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Very low for Cs and Sr over the pH range 3-9
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	Very low solubility ($<10^{-5}$ mol/l) in the pH range 3-9
Compositional Flexibility:	--
Gas Generation:	None
RCRA Compliance:	--
Conclusions:	The extreme insolubility of berlinite, coupled with the very low processing temperatures makes this a very attractive candidate waste form for high-alumina defense wastes.

ORGANIC BINDER SUMMARIES

ORGANIC BINDER SUMMARIES INDEX

NO. 1	AUTHOR:	
	TITLE:	DOW Polymer
	PUBLICATION:	Literature Provided by Heather Holmes Burns on CIF Project,
	DATE:	5/22/92
NO. 2	AUTHOR:	
	TITLE:	Low-Level Radioactive Waste Volume Reduction and Stabilization Technologies and Resource Manual
	PUBLICATION:	DOE/LLW-76T
	DATE:	12/88
NO. 3	AUTHOR:	
	TITLE:	Treatment of Spent Ion-Exchange Resins for Storage and Disposal
	PUBLICATION:	Technical Report Series No. 254
	DATE:	1985
NO. 4	AUTHOR:	
	TITLE:	A Waste Inventory Report for Reactor and Fuel Fabrication Facility Wastes
	PUBLICATION:	ONWI-20
	DATE:	1979
NO. 5	AUTHOR:	Akins, M.J.; Costomiris, G.; Delete, P.; Wilson, R.B.
	TITLE:	The Options for Solidifying Low Level Waste
	PUBLICATION:	Nuclear Engineering International, Vol. 28
	DATE:	3/83
NO. 6	AUTHOR:	Barletta, R.; Bowerman, B.; Davis, R.; Shea, C.
	TITLE:	Biodegradation Testing of Bitumen
	PUBLICATION:	BNL-NUREG-38999
	DATE:	1986
NO. 7	AUTHOR:	Bennet, B., et al.
	TITLE:	Conditioning Options for Magnox Fuel Element Debris
	PUBLICATION:	Radioactive Waste Management
	DATE:	1984

NO. 8	AUTHOR:	Buckley, L.; Clegg, B.; Oldham, W.
	TITLE:	Microbial Activity on Bituminized Radioactive Waste
	PUBLICATION:	Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 6
	DATE:	3/85
NO. 9	AUTHOR:	Colombo, P,; Neilson Jr., R.M.
	TITLE:	Properties of Radioactive Wastes and Waste Containers-First Topical Report
	PUBLICATION:	BNL-NUREG-50957
	DATE:	1979
NO. 10	AUTHOR:	Colombo, P.; Neilson Jr., R.M.
	TITLE:	Properties of Radioactive Wastes and Waste Containers
	PUBLICATION:	BNL-NUREG-50957
	DATE:	1977
NO. 11	AUTHOR:	Colombo, P.; Neilson Jr., R.M.
	TITLE:	Critical Review of the Properties of Solidified Radioactive Waste
	PUBLICATION:	BNL-NUREG-50591
	DATE:	1976
NO. 12	AUTHOR:	Dougherty, D.R.; Pietrzak, R.F.; Fuhrmann, M.; Colombo, P.
	TITLE:	Accelerated Leach Test(s) Program Annual Report
	PUBLICATION:	BNL-52042
	DATE:	1986
NO. 13	AUTHOR:	Fenner, O.H.
	TITLE:	Chemical and Environmental Properties of Plastics and Elastomers
	PUBLICATION:	Handbook of Plastics and Elastomers, C.A. Harper, ed.
	DATE:	1975
NO. 14	AUTHOR:	Filter, H.E.
	TITLE:	Vinyl Ester Solidification of Low-Level Radioactive Wastes
	PUBLICATION:	
	DATE:	1979

NO. 15	AUTHOR:	Fitzgerald, C.L.; Godbee, H.W.; Blanco, R.E.
	TITLE:	The Feasibility of Incorporating Radioactive Wastes in Asphalt or Polyethylene
	PUBLICATION:	Nuclear Applications and Technology, Vol. 9, No. 12
	DATE:	1970
NO. 16	AUTHOR:	Franz, E.M.; Colombo, P.
	TITLE:	Waste Form Evaluation Program, Final Report
	PUBLICATION:	BNL-51954
	DATE:	9/84
NO. 17	AUTHOR:	Franz, E.M.; Colombo, P.
	TITLE:	Waste Form Evaluation Program, Final Report
	PUBLICATION:	BNL-51954
	DATE:	9/84
NO. 18	AUTHOR:	Franz, E.M.; Colombo, P.
	TITLE:	Waste Form Evaluation Program, Final Report
	PUBLICATION:	BNL-51954
	DATE:	9/84
NO. 19	AUTHOR:	Franz, E.M.; Colombo, P.
	TITLE:	Waste Form Evaluation Program, Final Report
	PUBLICATION:	BNL-51954
	DATE:	9/84
NO. 20	AUTHOR:	Franz, E.M.; Heiser, J.H.; Colombo, P.
	TITLE:	Solidification of Problem Wastes, Annual Progress Report
	PUBLICATION:	BNL-52078
	DATE:	1987
NO. 21	AUTHOR:	Fuhrmann, M.; Neilson, R.M.; Colombo, P.
	TITLE:	A Survey of Agents and Techniques Applicable to the Solidification of LLW
	PUBLICATION:	BNL 51521
	DATE:	12/81
NO. 22	AUTHOR:	Graves, J.J.
	TITLE:	The Chemical Cleaning of Dresden Unit 1
	PUBLICATION:	Transactions of the American Nuclear Society, Vol. 28
	DATE:	1978

NO. 23	AUTHOR:	Kalb, P.D.; Colombo, P.
	TITLE:	An Economic Analysis of a Volume Reduction/Polyethylene Solidification System for Low-Level Radioactive Wastes
	PUBLICATION:	BNL-51866
	DATE:	1/85
NO. 24	AUTHOR:	Kalb, P.D.; Colombo, P.
	TITLE:	Polyethylene Solidification of Low-Level Wastes
	PUBLICATION:	BNL-51867
	DATE:	1984
NO. 25	AUTHOR:	Kalb, P.D.; Heiser, J.H.; Colombo, P.
	TITLE:	Polyethylene Encapsulation of Nitrate Salt Wastes: Waste Form Stability, Process Scale-up, and Economics
	PUBLICATION:	BNL-52293
	DATE:	7/91
NO. 26	AUTHOR:	Kopajtic, Z.; Laske, D.; Linder, H.P.; et al.
	TITLE:	Characterization of Bituminous Intermediate-Level Waste Products
	PUBLICATION:	Materials Research Society Symposium Proceedings, Vol. 21
	DATE:	1989
NO. 27	AUTHOR:	Kopajtic, Z.; Laske, D.; Linder, H.P.; et al.
	TITLE:	Characterization of Bituminous Intermediate-Level Waste Products
	PUBLICATION:	Materials Research Society Symposium Proceedings, Vol. 21
	DATE:	1989
NO. 28	AUTHOR:	Makhlis, F.A.
	TITLE:	
	PUBLICATION:	Radiation Physics and Chemistry of Polymers
	DATE:	1975

NO. 29	AUTHOR:	Mattus, A.J.; Kaczmarsky, M.M.
	TITLE:	Laboratory Performance Testing of an Extruded Bitumen Containing a Surrogate, Sodium Nitrate-Based, Low-Level Aqueous Waste
	PUBLICATION:	Proceedings of the Symp. on Waste Management at Tucson, AZ,
	DATE:	3/1-5/87
NO. 30	AUTHOR:	Miyanoga, I.; Sakata, S.; Ito, A.; Amano, H.
	TITLE:	Development of Radioactive Waste Management at the Japan Atomic Energy Research Institute
	PUBLICATION:	Nuclear Power and Its Fuel Cycle, Vol. 4, IAEA CN-36/156
	DATE:	1977
NO. 31	AUTHOR:	Moriyama, N.; Dojiri, S.; Honda, T.
	TITLE:	Solidification of Powdered Ion Exchange Resins with Polyethylene
	PUBLICATION:	Nuclear and Chemical Waste Management, Vol. 3, No. 2
	DATE:	1982
NO. 32	AUTHOR:	Moriyama, N.
	TITLE:	Incorporation of an Evaporator Concentrate on Polyethylene for BWR
	PUBLICATION:	Nuclear Chemical Waste Management
	DATE:	1982
NO. 33	AUTHOR:	Moriyama, N.
	TITLE:	Solidification of Powdered Ion Exchange Resins with Polyethylene
	PUBLICATION:	Nuclear Chemical Waste Management
	DATE:	1982
NO. 34	AUTHOR:	Moriyama, N.; Dojiri, S.; Matsuzuru, H.
	TITLE:	Incorporation of BWR's Evaporator Concentrate in Polyethylene
	PUBLICATION:	Nuclear and Chemical Waste Management, Vol. 3, No. 1
	DATE: 1982	

NO. 35	AUTHOR:	Muurinen, A.K.; Vuorinen, U.S.
	TITLE:	Testing of the Bituminized Ion-Exchange Resin Waste Products From a Nuclear Power Plant
	PUBLICATION:	International Atomic Energy Agency
	DATE:	1981
NO. 36	AUTHOR:	Neilson Jr., R.M.; Colombo, P.
	TITLE:	Properties of Radioactive Waste Containers Progress Report
	PUBLICATION:	No. 11, BNL-NUREG-51042
	DATE:	1979
NO. 37	AUTHOR:	Neilson Jr., R.M., Colombo, P.
	TITLE:	Solidification of Liquid Concentrate and Solid Waste Generated as By-Products of the Liquid Radwaste Treatment Systems in Light Water Reactors
	PUBLICATION:	BNL-NUREG-22839
	DATE:	1977
NO. 38	AUTHOR:	Neilson, Jr., R.M.; Colombo, P.
	TITLE:	Solidification of Liquid Concentrate and Solid Waste Generated as By-Products of the Liquid Radwaste Treatment System in Light Water Reactors
	PUBLICATION:	BNL-NUREG-22839
	DATE:	1977
NO. 39	AUTHOR:	Snellman, M.; Valkiainen, M.
	TITLE:	Long-Term Behavior of Bituminized Waste
	PUBLICATION:	Proceedings of the Symposium on Waste Management at Tucson, AZ
	DATE:	3/1-5/87
NO. 40	AUTHOR:	Soo, P.; Milian, L.W.; Piciulo, P.L.
	TITLE:	The Leachability and Mechanical Integrity of Simulated Decontamination Resin Wastes Solidified in Cement and Vinyl Ester-Styrene
	PUBLICATION:	Topical Report, BNL-NUREG-52149
	DATE:	1988

NO. 41	AUTHOR:	Letter from M. Tokar (NRC) to O. Wong encloses NRC Technical Evaluation Report on USE-61-002-P
	TITLE:	High-Strength Asphalt Solidification Process for Low-Level Radioactive Wastes
	PUBLICATION:	
	DATE:	8/2/91
NO. 42	AUTHOR:	Letter from M. Tokar (NRC) to Klein (WasteChem) encloses NRC Technical Evaluation Report on VRS-002
	TITLE:	"10 CFR 61" Waste Form Conformance Program for Solidified Process Waste Products Produced by a WasteChem Corporation Volume Reduction and Solidification (VRS) System
	PUBLICATION:	
	DATE:	1/22/88
NO. 43	AUTHOR:	U.S. Environmental Protection Agency
	TITLE:	
	PUBLICATION:	Toxicity Characteristic Leaching Procedure, 40 CFR 261
	DATE:	3/29/90
NO. 44	AUTHOR:	U.S. Department of Transportation
	TITLE:	
	PUBLICATION:	49 CFR 173, Appendix C, Fed. Reg. 46, 31294
	DATE:	6/15/81
NO. 45	AUTHOR:	Valkiainen, M.; Vuorinen, U.
	TITLE:	Long-Term Properties of TVO's Bituminized Resins
	PUBLICATION:	YJT-89-06
	DATE:	6/89

ORGANIC BINDER SUMMARIES **NO. 1**

TITLE:	DOW Polymer
AUTHORS:	
PUBLICATION:	Literature Provided by Heather Holmes Burns on CIF Project
DATE:	May 22, 1992
ORGANIZATION:	
SUMMARY:	Discussion of waste form and process consideration.

Waste Form:	DOW polymer (vinyl ester resin)
Waste Type:	Sodium sulfate salts and 5% ash fines
Waste Loading:	Waste/binder = 2.0/ 1.0
Development Status:	Commercial
Compressive Strength:	Solidified waste forms meet the NRC structural stability requirements.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Recent hazardous leachability test (TCLP tests) have proven that DOW Polymer waste forms can meet the EPA requirements for disposal for some waste types.
Immersion Stability:	--
Chemical Durability:	--
Compositional Flexibility:	The solid waste product is a uniform mixture of finely dispersed liquid particles in a continuous matrix.
Free Liquids:	When cured there is no free water
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	DOW system is capable of safely processing wet solid radioactive waste generated by light water reactors.

ORGANIC BINDER SUMMARIES **NO. 2**

TITLE:	Low-Level Radioactive Waste Volume Reduction and Stabilization Technologies and Resource Manual
AUTHOR:	
PUBLICATION:	DOE/LLW-76T
DATE:	December 1988
ORGANIZATION:	
SUMMARY:	Waste volume minimized during solidification process. Water content of liquid waste streams is removed during the solidification process.

Waste Form:	Bitumen
Waste Type:	Various (summary of systems) compatible with most low-level radioactive waste streams.
Waste Loading:	High waste loading capability
Development Status:	--
Compressive Strength:	Documented results (ASTM D-1074) show a range of compressive strengths between 55 and 300 psi with oxidized bitumen generally higher.
Thermal Stability:	Test Method: ASTM B553. Data supported conclusion that thermal cycling has no effect on bituminized waste forms.
Radiation Stability:	Samples exposed to total dose of 10^8 rad IAW NRC tests. All samples stabilized using bitumen performed well during radiation testing. Post-test compressive strengths were unchanged compared to pretest. Radiation has little or no effect on waste stabilized in bitumen.
Biological Stability:	Initial biodegradation tests detected bacterial growth on some test samples. Bitumen vendors, IAW, the NRC BTP, are conducting long-term tests to determine effects of growth on waste form stability.
Leach Resistance:	Test Method: ANS 16-1. Typical wastes with 60 wt% waste had range of leach indices from 8 to 14.

Immersion Stability:	Bitumen waste forms containing certain waste streams may crack or swell when exposed to water. Immersion can have a severe impact on compressive strength of waste forms. On the average, the test showed a decrease in compressive strength of 10-50%. The loss of compressive strength was directly proportional to increase in the amount of waste loading.
Free Liquid:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Some types of bitumen can be ignited at temperatures as low as 315° C
Conclusions:	Bitumen's performance in the tests prescribed in the NRC BTP indicates that bitumen is a good stabilization agent for most low-level waste streams. Its potential application to wastes other than those reported in the reviewed topical reports, including aqueous mixed, or hazardous wastes, must be evaluated on a case-by case basis.

ORGANIC BINDER SUMMARIES **NO. 3**

TITLE:	Treatment of Spent Ion-Exchange Resins for Storage and Disposal
AUTHOR:	
PUBLICATION:	Technical Report Series No. 254
DATE:	1985
ORGANIZATION:	International Atomic Energy Agency
SUMMARY:	For a 55 wt% loading of ion-exchange resins, volumes are 0.75 times the initial volume of ion-exchange resin. For ion-exchange ash in bitumen, final volumes are less than initial volumes.

Waste Form:	Bitumen (direct-distilled, oxidized, cracked, or emulsified)
Waste Type:	Spent ion-exchange resins
Waste Loading:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Bitumen can be successfully used for low and medium activity when the radiation dose does not exceed 10^7 Gy. Some H_2 generation.
Biological Stability:	Any bacteriological attack can be regarded as generally insignificant.
Leach Resistance:	Leach rates generally increase with harder bitumens, increased waste loading, and residual water in the waste form.
Immersion Stability:	Ion-exchange resins will absorb water with time once they are disposed of, although bitumen will impede this process. The swelling could lead to damage to the waste form repository.
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

ORGANIC BINDER SUMMARIES **NO. 4**

TITLE:	A Waste Inventory Report for Reactor and Fuel Fabrication Facility Wastes
AUTHOR:	
PUBLICATION:	ONWI-20
DATE:	1979
ORGANIZATION:	ONWI Library
SUMMARY:	Description of the physical and chemical characteristics of waste forms generated at light-water-cooled nuclear reactor power plants and nuclear fuel fabrication facilities.

Waste Form:	Urea formaldehyde
Waste Type:	Liquid waste
Waste Loading:	1:1
Development Status:	Commercial
Compressive Strength:	50 kg/cm^2
Thermal Stability:	--
Radiation Stability:	Moderate damage at 3×10^6 rad; severe damage at 2×10^7 rad
Biological Stability:	Susceptible to biodegradation
Leach Resistance:	Poor for ^{85}Sr and ^{137}Cs
Immersion Stability:	--
Free Liquids:	Produced during polymerization as low as 1%
Chemical Durability:	Resistant to oils, solvents, and grease, but dissolves in strong alkalis and acids
Compositional Flexibility:	Good in sealed system, water loss when exposed to air
Gas Generation:	Hydrogen gas produced during radiolysis
RCRA Compliance:	Self-extinguishing
Conclusions:	Means for the stabilization of low-level waste containing free liquids are needed to minimize the potential release of radionuclides during handling, offsite shipping, and disposal.

ORGANIC BINDER SUMMARIES **NO. 5**

TITLE:	The Options for Solidifying Low Level Waste
AUTHOR:	M.J. Akins; G. Costomiris; P. Delete; R.B. Wilson
PUBLICATION:	Nuclear Engineering International, Vol. 28
DATE:	March 1983
ORGANIZATION:	
SUMMARY:	Solidification of resin in bitumen results in volume reduction. Ash in bitumen and evaporator concentrates in bitumen do not result in volume reduction.

Waste Form:	Bitumen
Waste Type:	Various (summary of studies)
Waste Loading:	--
Development Status:	--
Compressive Strength:	Bitumen at ambient temperature exhibits good mechanical strength. On impact, the material will deform but will not normally break apart. The material will flow at high temperatures.
Thermal Stability:	Bitumen has demonstrated good thermal stability, but it is subject to melting/flowing at elevated temperatures which could be reached if exposed to fire or very hot sun-conditions.
Radiation Stability:	Bitumen can be successfully used for solidification of low and intermediate level wastes when integrated radiation dose does not exceed ~10^9 rad. As the dose approaches 10^9 rad, the chemical structure breaks down, leading to gas generation and a volume increase.
Biological Stability:	Based on the amount of organic constituents that leach from test specimens, it was determined that bitumen is not likely to be subject to significant biological attack.
Leach Resistance:	Some test results indicate bitumen leach rates are an order of magnitude lower than cements. However, if catastrophic swelling occurs as a result of immersion, the leach resistance is negligible.
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	--

ORGANIC BINDER SUMMARIES **NO. 5 (cont.)**

Compositional Flexibility:	Has low sensitivity to variations on waste feed and waste to binder ratio, but oil in feed must be <1%.
Gas Generation:	--
RCRA Compliance:	Ignition temperature for pure bitumen is ~600°F, and 750 to 900°F when mixed with radioactive waste.
Conclusions:	Bitumen has some advantages and some disadvantages when compared to other solidification agents. Each system must be evaluated on its merits in conjunction with all the specific parameters of its intended use.

ORGANIC BINDER SUMMARIES **NO. 6**

TITLE: Biodegradation Testing of Bitumen

AUTHOR: P. Barletta; B. Bowerman; R. Davis; C. Shea

PUBLICATION: BNL-NUREG-38999

DATE: 1986

ORGANIZATION: Brookhaven National Laboratory

SUMMARY:

Waste Form:	Bitumen (oxidized)
Waste Type:	N/A, the bitumen was tested without loading
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	Used Bartha-Pramer test method. See summary for results.
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Environmental factors have very little effect on the rate of biodegradation of bitumen. The mean rate is on the order of 5.5×10^{-4} cm/yr. Summary of other studies indicates microbial attack is more likely under aerobic conditions, and that many fungal and bacterial strains can degrade bitumen.

ORGANIC BINDER SUMMARIES **NO. 7**

TITLE:	Conditioning Options for Magnox Fuel Element Debris
AUTHOR:	B. Bennet; et al.
PUBLICATION:	Radioactive Waste Management
DATE:	1984
ORGANIZATION:	British Nuclear Energy Society, London
SUMMARY:	Work carried out on processes for the treatment of fuel element debris arising at Magnox nuclear power plants.

Waste Form:	Epoxy resin
Waste Type:	Magnox fuel element debris
Waste Loading:	40 vol%
Development Status:	Commercial
Compressive Strength:	19 MPa ± 1
Thermal Stability:	Reduction of compressive strength to 17 MPa ± 1 after 20 freeze/thaw cycles
Radiation Stability:	Increased compressive strength to 20 MPa ± 1 after irradiation to 1,000 Mrads
Biological Stability:	--
Leach Resistance:	For ^{137}Cs : 7 days = 1.0×10^{-4} cm/day; 100 days = 1.2×10^{-5} cm/day
Immersion Stability:	Decreased compressive strength to 17 MPa ± 1 after immersion inversion
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	90°C for 24 hours: 0.7 mL/kg,
RCRA Compliance:	Spontaneous ignition at 600°
Conclusions:	Epoxy resins exhibit superior chemical stability and leach resistance.

ORGANIC BINDER SUMMARIES **NO. 8**

TITLE: Microbial Activity on Bituminized Radioactive Waste

AUTHOR: L. Buckley; B. Clegg; W. Oldham

PUBLICATION: Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 6

DATE: March 1985

ORGANIZATION:

SUMMARY:

Waste Form:	Bitumen
Waste Type:	Nitrate salts
Waste Loading:	38 wt%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	Exposed to pseudomonas, bacillus, and other bacteria chosen for their affinity for bitumen.
Leach Resistance:	Test Method: "Leach Testing of Immobilized Radioactive Waste Solids, A Proposal for a Standard Method," E. Hespe, 1971. There were no statistical differences in the releases from the specimens inoculated with the culture, and those which were not.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance	--
Conclusions:	Statistically, there appeared to be no effect of microbial action on the bituminized waste forms.

ORGANIC BINDER SUMMARIES **NO. 9**

TITLE:	Properties of Radioactive Wastes and Waste Containers-First Topical Report
AUTHOR:	P. Colombo; R.M. Neilson, Jr.
PUBLICATION:	BNL-NUREG-50957
DATE:	1979
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Properties of waste forms and packages, solidification agents, and various processing parameters are discussed.

Waste Form:	Urea formaldehyde
Waste Type:	Bead resin waste slurry
Waste Loading:	Waste/UF = 2.6
Development Status:	Commercial
Compressive Strength:	ASTM C39-72: 78 psi ± 5
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	High concentration of organic carbon in free standing water
Leach Resistance:	IAEA Leach Test: ^{137}Cs = 1.4 x 10-6 cm/day; ^{85}Sr = 2.4 x 10-8 cm/day
Immersion Stability:	--
Free Liquids:	Often formed during polymerization
Chemical Durability:	--
Compositional Flexibility:	Weight loss due to water evaporation in ambient air
Gas Generation:	.915 cm^3/g from 10^7 R at 104 R/hr; .756 cm^3/g from 10^7 R at 105 R/hr
RCRA Compliance:	Flammability: ASTM D635-74; self-extinguishing
Conclusions:	This information is required to assess the safety and environmental impacts of radioactive waste disposal and to support quality control and assurance standards for radioactive waste treatment systems in operating facilities.

ORGANIC BINDER SUMMARIES **NO. 10**

TITLE: Properties of Radioactive Wastes and Waste Containers

AUTHOR: P. Colombo; R.M. Nielson, Jr.

PUBLICATION: BNL-NUREG-50957

DATE: 1977

ORGANIZATION: Brookhaven National Laboratory

SUMMARY: The properties of waste forms and packages resulting from the solidification of liquid concentrate and solid wastes generated as by-products of the liquid radioactive treatment systems in commercial BWRs and PWRs have been determined.

Waste Form:	Vinyl ester-styrene
Waste Type:	BWR chemical regenerative waste
Waste Loading:	Waste/binder = 1.65
Development Status:	Commercial
Compressive Strength:	ASTM C39-72: 2140 lb/in.^{2}
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	After four days immersion, small amounts of organic carbon was detected.
Leach Resistance:	Cumulative fraction release: Cs = 0.0548; Sr = 0.0513; Co = 0.155
Immersion Stability:	--
Free Liquids:	None
Chemical Durability:	Non-corrosive
Compositional Flexibility:	Weight loss due to evaporation of water
Gas Generation:	21 molecules/100 eV at an exposure of 10^5 rad
RCRA Compliance:	--
Conclusions:	Vinyl ester-styrene compares favorably with other types of solidifying agents.

ORGANIC BINDER SUMMARIES **NO. 11**

TITLE:	Critical Review of the Properties of Solidified Radioactive Waste
AUTHOR:	P. Colombo; R.M. Neilson, Jr.
PUBLICATION:	BNL-NUREG-50591
DATE:	1976
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Review and evaluation of existing information on the properties of various solidified wastes and waste packages being generated by commercial nuclear power reactors.

Waste Form:	Urea formaldehyde		
Waste Type and Loading:	Deep bed demineralizer resins	2.2%	
	Powdered demineralizer resins	2.6%	Weight
	25 wt% sodium sulfate	1.6%	Ratio
	Borates	1.5%	to
	Diatomaceous earth	2.7%	UF
Development Status:	Commercial		
Compressive Strength:	--		
Thermal Stability:	Poor due to high water content		
Radiation Stability:	Mild damage at 3×10^6 rad; moderate to severe damage at 2×10^7 rad		
Biological Stability:	--		
Leach Resistance:	Cs - 3×10^{-2} to 2×10^{-1} fractional per day		
Immersion Stability:	--		
Free Liquids:	.5% to 1% by volume, slightly acidic		
Chemical Durability:	Resists chemical attack		
Compositional Flexibility:	Prolonged drying leads to degradation of strength and increased leachability.		
Gas Generation:	Low toxicity gases produced (.5 molecules/100 eV)		
RCRA Compliance:	Self extinguishing		
Conclusions:	Conclusions are drawn regarding the current state of knowledge of solidified reactor waste properties.		

ORGANIC BINDER SUMMARIES **NO. 12**

TITLE: Accelerated Leach Test(s) Program Annual Report

AUTHOR: D.R. Dougherty; R.F. Pietrzak; M. Fuhrmann; P. Colombo

PUBLICATION: BNL-52042

DATE 1986

ORGANIZATION: Brookhaven National Laboratory

SUMMARY: Leachability evaluation of various solidification/waste form combination.

Waste Form: Bitumen
Waste Type: Sodium tetraborate (produced by neutralizing boric acid with sodium hydroxide)
Waste Loading: 40 wt%
Development Status: --
Compressive Strength: --
Thermal Stability: --
Radiation Stability: --
Biological Stability: --
Leach Resistance: 129 days: conductance (μmhos/cm) = 1630
Immersion Stability: --
Free Liquids: --
Chemical Durability: --
Compositional Flexibility: --
Gas Generation: --
RCRA Compliance: --
Conclusions: For waste form samples containing 40 wt% salt, the cumulative fraction released was 450 times greater than the baseline after 129 days. This is due to the number of interconnected salt particles providing a pathway for water.

ORGANIC BINDER SUMMARIES **NO. 13**

TITLE:	Chemical and Environmental Properties of Plastics and Elastomers
AUTHOR:	O.H. Fenner
PUBLICATION:	Handbook of Plastics and Elastomers, C.A. Harper, ed.
DATE:	1975
ORGANIZATION:	McGraw-Hill, New York
SUMMARY:	Provides a listing of physical properties and characteristics for various plastics and elastomers.

Waste Form:	Polyethylene
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	Unprotected polyethylene undergoes rapid ultraviolet degradation.
Gas Generation:	--
RCRA Compliance:	If ignited, polyethylene burns in a slow controlled manner at about 1 in./min. under ASTM D-635 conditions.
Conclusions:	Control of environmental exposure is critical to the integrity of polyethylene.

ORGANIC BINDER SUMMARIES **NO. 14**

TITLE: Vinyl Ester Solidification of Low-Level Radioactive Wastes

AUTHOR: H.E. Filter

PUBLICATION:

DATE: 1979

ORGANIZATION: Dow Chemical Company

SUMMARY:

Waste Form:	Vinyl Ester-Styrene
Waste Type:	--
Waste Loading:	--
Development Status:	Commercial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Low exposures have no significant effect on leachability. Exposures of 4 x 10^8 and 6 x 10^8 rad as much as tripled the leachability; however, this was still below a cumulative release of 5% in 100 days. Similar doses had no effect on the leachability of ^{60}Co.
Biological Stability:	--
Leach Resistance:	Prior heating to 538°C for ten minutes resulted in an acceleration of initial leaching of ^{137}Cs; however, the overall cumulative fraction leached began to approach that of the control after 90 days.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The Dow Polymer Solidification Process has advantages of low leachability and radiation stability.

ORGANIC BINDER SUMMARIES **NO. 15**

TITLE:	The Feasibility of Incorporating Radioactive Wastes in Asphalt or Polyethylene
AUTHOR:	C.L. Fitzgerald; H.W. Godbee; R. E. Blanco
PUBLICATION:	Nuclear Applications and Technology, Vol. 9, No. 12
DATE:	1970
ORGANIZATION:	Oak Ridge National Laboratory
SUMMARY:	Thermoplastic of chemical formula $(CH_2\text{-}CH_2)^x$ is melted and mixed with waste to form homogeneous solid (solid plastic monolith).

Waste Type:	Sodium borate, organic and inorganic solvents, low-density polyethylene lab-scale
Waste Form:	--
Waste Loading:	40 wt% evaporator concentrates, 50 wt% tributyl-phosphate
Development Status:	Experimental, limited application (at time of publication)
Compressive Strength:	300 kg/cm^2
Thermal Stability:	--
Radiation Stability:	10^6 rad, no effect; 10^7 - 10^9 rad caused slight shrinkage and discoloration
Biological Stability:	--
Leach Resistance:	Depends on waste type and loading, polyethylene type. Ranged from 3×10^{-3} g/cm^2 day to 1.5×10^{-6} g/cm^2 day.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	No gas was generated.
RCRA Compliance:	--
Conclusions:	Discusses feasibility of polyethylene for waste encapsulation. Limitations of their results can be attributed to the fact that only two types (of the hundreds available) of polyethylene were used, and processing technology was not optimized (only thin film evaporator used, which is not common practice in plastics industry).

ORGANIC BINDER SUMMARIES **NO. 16**

TITLE:	Waste Form Evaluation Program, Final Report
AUTHOR:	E.M. Franz; P. Colombo
PUBLICATION:	BNL-51954
DATE:	September 1984
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Presents data for assessing the acceptability of polyethylene waste forms to meet the requirements of 10 CFR 61.

Waste Form:	Polyethylene
Waste Type:	Sodium sulfate
Waste Loading:	50 wt%
Development Status:	Commercial
Compressive Strength:	ASTM D-1074: 2000 psi ± 100
Thermal Stability:	ASTM B-553
Radiation Stability:	^{60}Co gamma radiation to 10^8 rad at 3.6×10^6 rad/hr then compressive testing ASTM D-1074
Biological Stability:	ASTM G21 and G22
Leach Resistance:	ANS 16.1: leach index ^{85}Sr= 10.2, ^{137}Cs=9.9, ^{60}Co= 10.1
Immersion Stability:	54 wt%: 0.0% swelling after 90 days immersion in water
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The major criterion the waste form must meet after exposure (immersion, irradiation, etc.) is a compressive strength $\geq$ 50 psi.

ORGANIC BINDER SUMMARIES **NO. 17**

TITLE:	Waste Form Evaluation Program, Final Report
AUTHOR:	E.M. Franz; P. Colombo
PUBLICATION:	BNL-51954
DATE:	September 1984
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Presents data for assessing the acceptability of polyethylene waste forms to meet the requirements of 10 CFR 61.

Waste Form:	Polyethylene
Waste Type:	Boric acid
Waste Loading:	35 wt%
Development Status:	Commercial
Compressive Strength:	ASTM D-1074: 1800 psi ± 100
Thermal Stability:	ASTM B-553
Radiation Stability:	^{60}Co gamma radiation to 10^8 rad at 3.6 x 10^6 rad/hr then compressive testing ASTM D-1074
Biological Stability:	ASTM G21 and G22
Leach Resistance:	--
Immersion Stability:	0.2% swelling after 90 days immersion in water
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The major criterion the waste form must meet after exposure (immersion, irradiation, etc.) is a compressive strength ≥ 50 psi.

ORGANIC BINDER SUMMARIES **NO. 18**

TITLE:	Waste Form Evaluation Program, Final Report
AUTHOR:	E.M. Franz; P. Colombo
PUBLICATION:	BNL-51954
DATE:	September 1984
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Presents data for assessing the acceptability of polyethylene waste forms to meet the requirements of 10 CFR 61.

Waste Form:	Polyethylene
Waste Type:	Incinerator ash
Waste Loading:	20 wt%
Development Status:	Commercial
Compressive Strength:	ASTM D-1074: 1750 psi ± 140
Thermal Stability:	ASTM B-553
Radiation Stability:	^{60}Co gamma radiation to 10^8 rad at 3.6 x 10^6 rad/hr, then compressive testing ASTM D-1074
Biological Stability:	ASTM G21 and G22
Leach Resistance:	ANS 16.1 (25 wt%) : leach index ^{85}Sr=15.5, ^{137}Cs=12.5, ^{60}Co=13.9
Immersion Stability:	25 wt%: 0.5% swelling after 90 days immersion in water
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The major criterion the waste form must meet after exposure (immersion, irradiation, etc.) is a compressive strength $\geq$ 50 psi.

ORGANIC BINDER SUMMARIES **NO. 19**

TITLE: Waste Form Evaluation Program, Final Report

AUTHOR : E.M. Franz; P. Colombo

PUBLICATION: BNL-51954

DATE: September 1984

ORGANIZATION: Brookhaven National Laboratory

SUMMARY: Presents data for assessing the acceptability of polyethylene waste forms to meet the requirements of 10 CFR 61.

Waste Form:	Polyethylene
Waste Type:	Ion exchange resin
Waste Loading:	10 wt%
Development Status:	Commercial
Compressive Strength:	ASTM D-1074: 2100 psi ± 170
Thermal Stability:	ASTM B-553
Radiation Stability:	^{60}Co gamma radiation to 10^8 rad at 3.6 x 10^6 rad/hr, then compressive testing ASTM D-1074
Biological Stability:	ASTM G21 and G22
Leach Resistance:	ANS 16.1 : leach index ^{85}Sr=16.2, ^{137}Cs=18.2, ^{60}Co= 13.6
Immersion Stability:	20 wt%: 0.0% swelling after 90 days immersion in water
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The major criterion the waste form must meet after exposure (immersion, irradiation, etc.) is a compressive strength ≥ 50 psi.

ORGANIC BINDER SUMMARIES **NO. 20**

TITLE: Solidification of Problem Wastes, Annual Progress Report

AUTHOR: E.M. Franz; J.H. Heiser; P. Colombo

PUBLICATION: BNL-52078

DATE: 1987

ORGANIZATION: Brookhaven National Laboratory

SUMMARY: Development and evaluation of solidification systems for sodium nitrate waste and compacted waste.

Waste Form:	Polyethylene	
Waste Type:	Sodium nitrate	
Waste Loading:	30-70%	
Development Status:	Laboratory scale	
Compressive Strength:	ASTM D-695:	Compressive Strength (psi)
	30 wt%	2370
	50 wt%	1920
	60 wt%	2200
	70 wt%	1020
Thermal Stability:	--	
Radiation Stability:	--	
Biological Stability:	--	
Leach Resistance:	ANS 16.1:	Leach Index
	30 wt%	11.1
	50 wt%	9.7
	60 wt%	9.0
	70 wt%	7.8
Immersion Stability:	90 days in water:	Compressive Strength (psi)
	30 wt%	2550
	50 wt%	1920
	60 wt%	2310
	70 wt%	720
Free Liquids:	--	
Chemical Durability:	--	
Compositional Flexibility:	--	
Gas Generation:	--	
RCRA Compliance:	--	
Conclusions:	Polyethylene waste forms exhibit good leaching characteristics, high compressive strength (700-2,600 psi) and high leading efficiencies (70 wt% sodium nitrate)	

ORGANIC BINDER SUMMARIES **NO. 21**

TITLE:	A Survey of Agents and Techniques Applicable to the Solidification of LLW
AUTHOR:	M. Fuhrmann; R.M. Neilson; P. Colombo
PUBLICATION:	BNL 51521
DATE:	December 1981
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Use of a twin screw extruder reported at Japan Atomic Energy Research Institute, and in the Netherlands .

Waste Stream:	Ion exchange resin beads
Waste Form:	Low-density polyethylene
Waste Loading:	50 wt% bead resin
Development Status:	Experimental, bench-scale
Compressive Strength:	300 kg/cm^2
Thermal Stability:	--
Radiation Stability:	33% drop in compressive strength reported after gamma irradiation dose of 10^8 rad.
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Polyethylene by itself does not spontaneously ignite on heating to temperatures of 550°C.
Conclusions:	This is a literature study comparing solidification agents applicable to LLW. Report is a comprehensive overview of many solidification agents including hydraulic cements, bitumen, polyethylene, urea-formaldehyde, polyester and epoxy thermosetting polymers, mineralization processes, glass, polymer modified gypsum cement, and polymer impregnated concrete. Numerous figures and tables reprinted from original sources enhance readability.

ORGANIC BINDER SUMMARIES **NO. 22**

TITLE:	The Chemical Cleaning of Dresden Unit I
AUTHOR:	J.J. Graves
PUBLICATION:	Transactions of the American Nuclear Society, Vol. 28
DATE:	1978
ORGANIZATION:	
SUMMARY:	Discussion of Dow Solidification system use in decontaminating a nuclear power reactor.

Waste Form:	Dow polymer
Waste Type:	Various wastes produced during decontamination of nuclear power plants
Waste Loading:	--
Development Status:	Commercial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Exposure to 600 Mrad has no significant effect on mechanical properties or leachability.
Biological Stability:	--
Leach Resistance:	Low leachability
Immersion Stability:	--
Free Liquid:	No free liquid
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The Dow solidification process is superior to any other commercial solidification process in waste form behavior and characteristics.

ORGANIC BINDER SUMMARIES **NO. 23**

TITLE:	An Economic Analysis of a Volume Reduction/Polyethylene Solidification System for Low-Level Radioactive Wastes
AUTHOR:	P.D. Kalb; P. Colombo
PUBLICATION:	BNL-51866
DATE:	January 1985
ORGANIZATION:	Brookhaven National Lab
SUMMARY:	Fluidized bed calcination/incineration as a waste pretreatment, coupled, with encapsulation in LDPE. Levelized revenue requirement technique used to compare volume reduction/polyethylene encapsulation with solidification of aqueous streams in cement.

Waste Form:	Low-density polyethylene
Waste Type:	Aqueous evaporator concentrates and ion exchange resins
Waste Loading:	60 wt% sodium sulfate, 30 wt% boric acid, and 25 wt% incinerator ash (conservative waste loadings selected intentionally)
Development Status:	Study of economic feasibility for full-scale implementation
Compressive Strength:	Not applicable
Thermal Stability:	--
Radiation Stability	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	If current trends in escalation rates of cost components continue, the volume reduction/polyethylene solidification option will be cost effective for both boiling water and pressurized water reactors. Data indicate that a minimum net annual savings of $0.8 million/yr (for a PWR with short shipping distance to disposal site) and a maximum savings of $9 million/yr for a BWR with long shipping distance) can be achieved (savings in 1984 dollars).

ORGANIC BINDER SUMMARIES **NO. 24**

TITLE:	Polyethylene Solidification of Low-Level Wastes
AUTHOR:	P.D. Kalb; P. Colombo
PUBLICATION:	BNL - 51867
DATE:	1984
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Low density polyethylene is melted at 130 - 150°C and mixed with waste to form homogeneous solid, using single screw extruder. Static hopper replaced with volumetric feeders to provide precise control of waste/binder ratios.

Waste Form:	Low density polyethylene
Waste Type:	Sodium sulfate, boric acid, incinerator ash, ion exchange resin beads
Waste Loading:	70 wt% sodium sulfate, 50 wt% boric acid, 40 wt% incinerator ash, 30 wt% ion exchange resin beads.
Development Status:	Bench-scale (1.25-in.) single screw extruder
Compressive Strength:	ASTM D-621(deformation of plastics under 100 psi load) Maximum deformation when subjected to 100 psi load was 0.36%.
Thermal Stability:	Thermal cycling conducted according to NRC protocol. After 30 cycles between -40 and +60°C, no change in waste form mechanical properties was detected.
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	ANS 16.1 90 day (^{137}Cs, ^{85}Sr, ^{60}Co). Dependent on waste type and loading. Leaching from ash waste forms ranged between 1×10^{-3} and 4×10^{-4} for loadings up to 35 wt%. All 3 isotopes had similar releases from sodium sulfate waste forms (about 5×10^{-3} for 10 wt%) which increased with waste loading (about 2×10^{-2} 50 wt%) for sodium sulfate.
Immersion Stability:	90 day water immersion testing conducted according to NRC protocol. Samples were then measured for any change in dimensions. Swelling was less than 2% for all samples, except ion exchange resin waste forms with loadings exceeding 30 wt%.
Free Liquids:	--
Chemical Durability:	--

Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	This work examined many types of low density polyethylene (varying in density and melt index) to optimize the selection of a plastic with optimal properties for waste encapsulation. Process development study compared effectiveness of several processing technologies - single screw extrusion was found to be most effective and efficient. Feed system modified for improved QA. Detailed process control parameters (temperature zone setting, screw speeds, motor draw, melt temperatures and pressures) are all reported at length in the appendix.

ORGANIC BINDER SUMMARIES **NO. 25**

TITLE:	Polyethylene Encapsulation of Nitrate Salt Wastes: Waste Form Stability, Process Scale-up, and Economics
AUTHOR:	P.D. Kalb; J.H. Heiser; P. Colombo
PUBLICATION:	BNL 52293
DATE:	July 1991
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Low density polyethylene is melted at 130 - 150°C and mixed with waste to form homogeneous solid, using single screw extruder. Static hopper replaced with volumetric feeders to provide precise control of waste/binder ratios. This report assessed potential long-term durability of polyethylene waste forms by examining potential failure mechanisms including biodegradation, radiation, chemical attack, flammability, environmental stress cracking, and photodegradation. A review of the literature was supplemented by waste form performance testing for several key potential failure mechanisms including biodegradation, radiation and flammability.

Waste Form:	Low-density polyethylene
Waste Type:	Nitrate salts
Waste Loading:	70 dry wt% sodium nitrate
Development Status:	Bench-scale: formulation development and performance testing complete. Full-scale: feasibility test at production-scale successful. Full-scale demonstration using surrogate waste planned for FY-1993.
Compressive Strength:	ASTM D-695, Standard Method of Test for Compressive Properties of Rigid Plastics. Polyethylene waste form compressive yield strength varies with loading from a minimum of > 1,000 psi (70 wt% $NaNO_3$) to a maximum of >2,350(30 wt% $NaNO_3$); NRC minimum strength for waste forms other than cement is 60 psi. Compressive strength data for cores taken from full-scale test specimen were within 8% of lab-scale data.
Thermal Stability:	--

Radiation Stability:	Low density polyethylene polymer chains become more heavily cross-linked when subjected to ionizing radiation, which increases mechanical strength and reduces permeability. Polyethylene waste forms subjected to 10^8 rad total absorbed dose of gamma irradiation increased in strength by about 18% over un-irradiated control samples.
Biological Stability:	Results from literature which indicate that polyethylene is highly resistant to microbial degradation were confirmed by biodegradation testing on polyethylene waste forms (ASTM G-21 and G-22).
Leach Resistance:	ANS 16.1 90 day, sodium leachability. Leaching of soluble salts is dependent on waste loading. Leaching index ranged from 11.1 for polyethylene waste forms containing 30 wt% $NaNO_3$ to 7.8 for 70 wt% $NaNO_3$. These results represent 2 to 5 orders of magnitude lower leachability than NRC minimum leach index value of 6.0.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Flammability testing indicated that polyethylene self-ignition occurs at 430°C (the material is self-extinguishing below this temperature) compared with normal process temperatures of <150°C.
Conclusions:	Following bench-scale development and testing, a scale-up feasibility test was conducted for simulated $NaNO_3$ waste using a 4.5-in. production-scale extruder with a maximum output of 2000 lbs/hr. This test indicated that at least 60 wt% $NaNO_3$ could be successfully encapsulated in polyethylene using production equipment, bench- and full-scale process data were comparable, and the waste form product was homogeneously mixed. QA/performance testing for cored specimens from the full-scale waste form including compressive strength, thermal cycling, irradiation and biodegradation testing were in close agreement with lab-scale data and were well above minimum NRC standards for low-level waste. An economic analysis for encapsulation of Rocky Flats nitrate salt resulted in net cost savings ranging between $1.5 and 2.7 million, compared with conventional cement processes.

ORGANIC BINDER SUMMARIES **NO. 26**

TITLE:	Characterization of Bituminous Intermediate-Level Waste Products
AUTHOR:	Z. Kopajtic; D. Laske; H.P. Linder; et al.
PUBLICATION:	Materials Research Society Symposium Proceedings, Vol. 21
DATE:	1989
ORGANIZATION:	Materials Research Society Summary:

SUMMARY:

Waste Form:	60 wt% distilled bitumen
Waste Type:	Swiss intermediate level radioactive waste
Waste Loading:	40 wt% solids
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Gamma irradiated to approximately 5 MGy at approximately 3.8 kGy/hr
Biological Stability:	--
Leach Resistance:	Test Method: ISO-6961-1982 Long Term Leach Testing of Solidified Radioactive Waste Forms. Swelling and cracking observed, relatively low leach rates, although leach rates are slightly higher for irradiated forms.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	As an irradiation effect, swelling and gas evolution (mainly H_2)
RCRA Compliance:	--
Conclusions:	External gamma irradiation at a high dose rate caused intense swelling in both oxidized and distilled bituminous waste products. The amount of swelling depends on factors such as dose rate, total dose, type of bitumen, and quantity of the waste.

ORGANIC BINDER SUMMARIES **NO. 27**

TITLE:	Characterization of Bituminous Intermediate-Level Waste Products
AUTHOR:	Z. Kopajtic; D. Laske; H.P. Linder; et al.
PUBLICATION:	Materials Research Society Symposium Proceedings, Vol. 21
DATE:	1989
ORGANIZATION:	Materials Research Society

SUMMARY:

Waste Form:	63 wt% blown bitumen
Waste Type:	Simulated inactive $NaNO_3$
Waste Loading:	37 wt%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Gamma irradiated to approximately 5 MGy at approximately 3.8 kGy/hr
Biological Stability:	--
Leach Resistance:	Test Method: ISO-6961-1982 Long Term Leach Testing of Solidified Radioactive Waste Forms. Swelling and cracking observed, relatively low leach rates, although leach rates are slightly higher for irradiated forms.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	As an irradiation effect, swelling and gas evolution (mainly H_2)
RCRA Compliance:	--
Conclusions:	External gamma irradiation at a high dose rate caused intense swelling in both oxidized and distilled bituminous waste products. The amount of swelling depends on factors such as dose rate, total dose, type of bitumen, and quantity of the waste.

ORGANIC BINDER SUMMARIES **NO. 28**

TITLE:	
AUTHOR:	F.A. Makhlis
PUBLICATION:	Radiation Physics and Chemistry of Polymers
DATE:	1975
ORGANIZATION:	John Wiley and Sons, New York
SUMMARY:	Influence of the physical state and temperature on radiochemical transformations in polymers.

Waste Form:	Polyethylene
Waste Type:	--
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability :	--
Radiation Stability:	Observed changes in melting point and gel content depend only on total dose and are not affected by the rate the dose is delivered.
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	The use of polymers in atomic technology is limited due to their relatively low radiation stability.

ORGANIC BINDER SUMMARIES **NO. 29**

TITLE:	Laboratory Performance Testing of an Extruded Bitumen Containing a Surrogate, Sodium Nitrate-Based, Low-Level Aqueous Waste
AUTHORS:	A.J. Mattus; M.M. Kaczmarsky
PUBLICATION:	Proceedings of the Symposium on Waste Management at Tucson, Arizona
DATE:	March 1-5, 1987
ORGANIZATION:	
SUMMARY:	Always results in volume reduction for wastes which contain volatile solvents.

Waste Form:	Bitumen (ASTM D-312) Type III (oxidized)
Waste Type:	Surrogate low-level mixed liquid waste containing ~30 wt% sodium nitrate, plus eight heavy metals, cold Cs and Sr.
Waste Loading:	Waste Loading of 40 wt%, 50 wt%, and 60 wt%
Development Status:	--
Compressive Strength:	Test Method ASTM D-1074. Compressive strengths range from ~249 psi for pure bitumen to ~622 for the 60 wt% loading.
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Test Method ANS 16. 1. Leach indices for Cs, Sr, as well as other heavy metals range from 8.0 to >14.1 for all samples.
Immersion Stability:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	Test Method: EP Tox. All waste forms/waste loading easily passed the test. For most of the 8 EPA metals, the concentration in the leachates was at/near the LLD.
Conclusions:	Regulatory performance testing of extruded bitumen has shown that the relatively viscous form of oxidized bitumen used performed well under several required performance tests. The extruder bitumen process has been able to achieve high waste loading and high VRE, and has still resulted in a waste form capable of offering superior leach resistance.

ORGANIC BINDER SUMMARIES **NO. 30**

TITLE:	Development of Radioactive Waste Management at the Japan Atomic Energy Research Institute
AUTHOR:	I.S. Miyango; A.I. Sakata; H. Amano
PUBLICATION:	Nuclear Power and Its Fuel Cycle, Vol. 4, IAEA CN-36/156
DATE:	1977
ORGANIZATION:	Japan Atomic Energy Research Institute
SUMMARY:	Discussion of waste forms and their process considerations.

Waste Form:	Low-density polyethylene
Waste Type:	Ion exchange resin beads
Waste Loading:	50 wt% bead resin
Development Status:	Bench-scale
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Leach Resistance:	Release of ^{137}Cs was as low as 0.1% after one year.
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

ORGANIC BINDER SUMMARIES **NO. 31**

TITLE: Solidification of Powdered Ion Exchange Resins with Polyethylene

AUTHOR: N. Moriyama; S. Dojiri; T. Honda

PUBLICATION: Nuclear and Chemical Waste Management, Vol. 3, No. 2

DATE: 1982

ORGANIZATION: Japan Atomic Energy Research Institute

SUMMARY: Low density polyethylene is melted at 160°C and mixed with waste to form homogeneous solid, using batch wiped film stirrer.

Waste Form:	Low-density polyethylene
Waste Type:	Powdered ion exchange resins
Waste Loading:	40 - 50 wt% powdered ion exchange resins
Development Status:	Experimental (lab-scale), limited application at time of publication
Compressive Strength:	ASTM D-6952 test. 31- 237 kg/cm^2
Thermal Stability:	--
Radiation Stability:	Radiation resistance testing showed slight increases in strength with doses ranging from 10^7 - 10^9 rad and 50 wt% powdered resin.
Biological Stability:	--
Leach Resistance:	IAEA leach test. Fraction of ^{60}Co released in 200 days: 3.1 x 10^{-4}. ^{137}Cs fraction release below detection limit of 3 x 10^{-5}. ^{60}Co diffusion coefficient: 4.5 x 10^{-10} cm^2/day for initial 64 days, 6.7 x 10^{-12} cm^2/day for remaining data.
Immersion Stability:	Water immersion for 1200 days caused some swelling and cracking in samples containing waste loadings of more than 40 wt%.
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	Minimal gas generation measured: 2 x 10^{-2} cm^3/g Mrad.
RCRA Compliance:	--
Conclusions:	--

ORGANIC BINDER SUMMARIES **NO. 32**

TITLE:	Incorporation of an Evaporator Concentrate on Polyethylene for BWR
AUTHOR:	N. Moriyama
PUBLICATION:	Nuclear Chemical Waste Management
DATE:	1982
ORGANIZATION:	
SUMMARY:	The adaptability of polyethylene solidification method to an evaporator concentrate produce on a boiling water reactor (BWR).

Waste Form:	Polyethylene
Waste Type:	Sodium sulfate
Waste Loading:	40 to 70 wt%
Development Status:	--
Compressive Strength:	ASTM D-695 and D-256
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	40-50 wt%: diffusion coefficient of sodium range from 10^{-7} to 10^{-6} cm^2/day
Immersion Stability:	No swelling, destruction or deterioration after 120 days
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Polyethylene products are superior to both cement and bitumen products with respect to mechanical property, leachability, water resistance, and volume reduction effect.

ORGANIC BINDER SUMMARIES **NO. 33**

TITLE:	Solidification of Powdered Ion Exchange Resins with Polyethylene
AUTHOR:	N. Moriyama
PUBLICATION:	Nuclear Chemical Waste Management
DATE:	1982
ORGANIZATION:	
SUMMARY:	The adaptability of polyethylene solidification method to spent powdered ion exchange resins.

Waste Form:	Polyethylene
Waste Type:	Spent powdered ion exchange resin
Waste Loading:	50 wt%
Development Status:	--
Compressive Strength:	ASTM D-695 and D-256: 230 kg/cm^2
Thermal Stability:	--
Radiation Stability:	Compressive strength increased with increased irradiation. Samples become hard and brittle in doses above 6.9 x 10^8 rad.
Biological Stability:	--
Leach Resistance:	Fractional after 200 days: ^{60}Co = 3.1 x 10^{-4}; ^{137}Cs = undetectable
Immersion Stability:	Crack formation after 1,200 days
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	2.0 to 2.4 x 10^{-2} cm^3/g·Mrad
RCRA Compliance:	--
Conclusions:	The product with 50 wt% waste has a compressive strength of 203 kg/cm^2, and low leachability.

ORGANIC BINDER SUMMARIES **NO. 34**

TITLE: Incorporation of BWR's Evaporator Concentrate in Polyethylene

AUTHOR: N. Moriyama; S. Dojiri; H. Matsuzuru

PUBLICATION: Nuclear and Chemical Waste Management, Vol. 3, No. 1

DATE: 1982

ORGANIZATION: Japan Atomic Energy Research Institute

SUMMARY: Low density polyethylene is melted at 190°C and mixed with waste to form homogeneous solid, using batch wiped film stirrer.

Waste Form:	Low-density polyethylene
Waste Type:	Sodium sulfate
Waste Loading:	50 - 70 wt% sodium sulfate evaporator concentrates
Development Status:	Experimental, limited lab-scale application at time of publication
Compressive Strength:	ASTM D-695: 137 - 327 kg/cm^2
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Depends on waste loading, polyethylene type. Diffusion coefficient ranged from 3×10^{-4} cm^2/day (70 % loading) to 8.5×10^{-8} cm^2/day (40 % loading).
Immersion Stability:	Water immersion for 120 days caused no increased swelling or weight gain.
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Batch-wiped film mixer used instead of a screw extruder, which is commonly used in plastics industry.

ORGANIC BINDER SUMMARIES **NO. 35**

TITLE:	Testing of the Bituminized Ion-Exchange Resin Waste Products from a Nuclear Power Plant
AUTHOR:	A.K. Muurinen; U.S. Vuorinen
PUBLICATION:	
DATE:	1981
ORGANIZATION:	International Atomic Energy Agency

SUMMARY:

Waste Form:	Bitumen
Waste Type:	Finnish nuclear power plant low- and medium-level wet wastes (ion-exchange resins, filter masses, and evap. conc.)
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	Samples exposed to ~52 Mrad over ~6 days. The waste swelled ~20 to 25% as a result of irradiation.
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Radiation somewhat affects the properties of waste products and of pure bitumen. Post-irradiation tests performed included relative density, softening point, breaking point, flash point, and water content. Activity distributions were also measured.

ORGANIC BINDER SUMMARIES **NO. 36**

TITLE:	Properties of Radioactive Waste Containers Progress Report
AUTHOR:	R.M. Neilson, Jr.; P. Colombo
PUBLICATION:	No. 11, BNL-NUREG-51042
DATE:	1979
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Effects of radiation exposure on Urea Formaldehyde waste form leachability.

Waste Form: Urea Formaldehyde
Waste Type: Diatomaceous earth slurry
Waste Loading: waste/UF = 2.0 by weight
Development Status: Commercial
Compressive Strength: --
Thermal Stability: --
Radiation Stability: --
Biological Stability: --
Leach Resistance: Cumulative Fraction Release

Rad Exposure (^{60}Co)	Strontium	Cesium
10^5	2.824	0.043
10^6	2.741	0.038
10^7	3.165	0.057
10^8	3.706	0.151

Immersion Stability: --
Free Liquids: --
Chemical Durability: --
Compositional Flexibility: --
Gas Generation: --
RCRA Compliance: --
Conclusions: A radiation dose dependence was found for both cesium and strontium release from urea formaldehyde waste forms.

ORGANIC BINDER SUMMARIES **NO. 37**

TITLE:	Solidification of Liquid Concentrate and Solid Waste Generated as By-Products of the Liquid Radwaste Treatment Systems in Light Water Reactors
AUTHOR:	R.M. Neilson, Jr.; P. Colombo
PUBLICATION:	BNL-NUREG-22839
DATE:	1977
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Overview of solidification process and non-specific comparison of products.

Waste Form:	Urea Formaldehyde
Waste Type:	Various
Waste Loading:	Highly dependent on waste type
Development Status:	Commercial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	5×10^{-1} to 5×10^{3} g/(cm^2-day)
Immersion Stability:	--
Free Liquids:	Acidic free standing water produced during polymerization
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Properties relevant to the evaluation of solidified waste forms are identified and relative comparisons are made for wastes solidified by various processes.

ORGANIC BINDER SUMMARIES **NO. 38**

TITLE:	Solidification of Liquid Concentrate and Solid Waste Generated as By-Products of the Liquid Radwaste Treatment System in Light Water Reactors
AUTHOR:	R.M. Nielson, Jr.; P. Colombo
PUBLICATION:	BNL-NUREG-22839
DATE:	1977
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	Table listing nonspecific properties of Dow polymer waste forms.

Waste Form:	Dow polymer
Waste Type:	Various
Waste Loading:	--
Development Status:	Commercial
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	10^{-3} to 10^{-5} g/(cm^2-day)
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Stability:	--
Gas Generation:	--
RCRA Compliance:	Not ignitable
Conclusions:	When compared to other waste solidification systems, the Dow polymer is a viable choice.

ORGANIC BINDER SUMMARIES **NO. 39**

TITLE: Long-Term Behavior of Bituminized waste

AUTHOR: M. Snellman; M. Valkiainen

PUBLICATION: Proceedings of the Symposium on Waste Management at Tucson, Arizona

DATE: March 1-5, 1987

ORGANIZATION:

SUMMARY:

Waste Form:	Bitumen
Waste Type:	Ion-exchange resins
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	Below 0°C bitumen waste forms are brittle and may be cracked by mechanical impact. Cracks may heal if forms are reheated to room temperature.
Radiation Stability:	Radiolysis gas (mostly hydrogen) is generated at a rate and in an amount proportional to the absorbed radiation dose.
Biological Stability:	Anaerobic microbial attack on a monolithic bitumen block takes place extremely slowly.
Leach Resistance:	Samples were leached in cement equilibrated and distilled water using a test method developed by K. Brodersen. Leaching tends to be much faster in "cement water."
Immersion Stability:	If swelling of bitumenized ion-exchange resins is restricted, but uptake of water is possible, considerable pressure may develop.
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	Waste loadings up to 50%
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Behavior of waste product depends on the solidification process parameters. In the context of this study, no unacceptable long-term effects have been found caused by bitumen itself, but swelling must be taken into account for disposal.

ORGANIC BINDER SUMMARIES **NO. 40**

TITLE:	The Leachability and Mechanical Integrity of Simulated Decontamination Resin Wastes Solidified in Cement and Vinyl Ester-Styrene
AUTHOR:	P. Soo; L.W. Milian; P.L. Piciulo
PUBLICATION:	Topical Report, BNL-NUREG-52149
DATE:	1988
ORGANIZATION:	Brookhaven National Laboratory
SUMMARY:	The release rates of organic decontamination reagents were measured for mixed-bed resins solidified in vinyl ester styrene.

Waste Form:	Vinyl ester-styrene
Waste Type:	Simulated LOMI Waste
Waste Loading:	50 wt%
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	Cumulative release fraction = .088 after 144 days for waste form size of 5 cm x 10 cm.
Immersion Stability:	No cracking, spalling, swelling, etc. were observed after 540 to 630 days immersion.
Free Liquids:	--
Chemical Durability:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Vinyl ester-styrene waste forms have superior leaching and compositional stability properties compared to cement based waste forms.

ORGANIC BINDER SUMMARIES **NO. 41**

TITLE: High-Strength Asphalt Solidification Process for Low-Level Radioactive Wastes

AUTHOR: Letter from M. Tokar (NRC) to O. Wong encloses NRC Technical Evaluation Report on USE-61-002-P

DATE: August 2, 1991

SUMMARY:

Waste Form:	Bitumen (distilled)
Waste Type:	Boric acid concentrates
Waste Loading:	--
Development Status:	--
Compressive Strength:	Test Method: ASTM D-1074. Pure asphalt compressive strength was 430 psi. Compressive strength for boric acid wastes were 1055 to 1185 psi.
Thermal Stability:	Test Method: ASTM B553. Post-test compressive strengths for boric acid wastes were >900 psi
Radiation Stability:	Samples exposed to 10^8 rad. Post-test compressive strengths for boric acid wastes were >800 psi.
Biological Stability:	Test Method: ASTM G21 & G22. Post-test compressive strengths were 850 to 1085 psi. One sample had growth and was retested using Bartha Pramer, which it passed.
Leach Resistance:	Test Method: ANS 16. 1. Leach indices ranged from 7.77 to 10.91 in demineralized water and from 7.65 to 9.90 in simulated sea-water
Immersion Stability:	Following immersion for 90 days, one waste form (pH = 7, waste loading = 50.68 wt%) had a compressive strength of -96 psi. Another (pH = 9, waste loading = 43.85 wt%) had a compressive strength of ~1075 psi.
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	Up to 12 wt% solids. Limited to pH=9, waste loading < 40 wt%.
Gas Generation:	--
RCRA Compliance:	Under normal conditions, the waste form will not cause fires. Minimum flash point is 500°F
Conclusions:	The boric acid waste form has been approved by the NRC, under certain conditions. Other wastes may be qualified for use with this binder system following future testing.

ORGANIC BINDER SUMMARIES **NO. 42**

TITLE:	"10 CFR 61" Waste Form Conformance Program for Solidified Process Waste Products Produced by a WasteChem Corporation Volume Reduction and Solidification (VRS) System
AUTHOR:	Letter from M. Tokar (NRC) to Klein (WasteChem), encloses NRC Technical Evaluation Report on VRS-002
PUBLICATION:	
DATE:	January 22, 1988

SUMMARY:

Waste Form:	Bitumen (ASTM D-312, Type III)
Waste Type:	Simulated generic process wastes from commercial PWRs and BWRs
Waste Loading:	--
Development Status:	--
Compressive Strength:	Test Method: ASTM D-1074. At 10% sample deformation, results ranged from 108 psi to 262 psi.
Thermal Stability:	Test Method: ASTM B553. Post-test compressive strengths range from 81.2 psi to 276 psi.
Radiation Stability:	Samples exposed to 108 Mrad, over a 239.9 hour period had post-irradiation compressive strengths of 220 and 270 psi.
Biological Stability:	Test Method: Bartha-Pramer. Total carbon loss from waste forms was projected to be <10% over 300 years.
Leach Resistance:	Test Method: ANS 16. 1. Leach index range was 8.07 to 13.76
Immersion Stability:	Immersion for 90 days in deionized water. Compressive strength range after immersion, 74 psi to 250 psi. Waste loading for simulated evaporator concentrate was decreased to 25%. Higher loadings led to swelling and disintegration.
Free Liquids:	None
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	NRC approved the WasteChem topical report with limitations on waste loading, (none are greater than 60 wt% waste). In addition, waste forms must be contained in 55-gal drums or approved HICs. Backfill should be used if 55-gal drums are used.

ORGANIC BINDER SUMMARIES **NO. 43**

TITLE:

AUTHOR: U.S. Environmental Protection Agency

PUBLICATION: Toxicity Characteristic Leaching Procedure, 40 CFR 261

DATE: March 29, 1990

ORGANIZATION: U.S. Environmental Protection Agency

SUMMARY: Testing to determine the mobility of both organic and inorganic analytes present in liquids, solids, and multiphasic wastes.

Waste Form:	Polyethylene
Waste Type:	Sodium nitrate salt containing sufficient chromium to be classified as hazardous
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Toxicity Characteristic Leaching Procedure recently replaced the EP Toxicity Test in 40 CFR 261.

ORGANIC BINDER SUMMARIES **NO. 44**

TITLE:	
AUTHOR:	U.S. Department of Transportation
PUBLICATION:	49 CFR 173, Appendix C, Federal Register 46, 31294
DATE:	June 15,1981
ORGANIZATION:	U.S. Department of Transportation
SUMMARY:	Vibration testing for hazardous waste form packaging that is to be transported.

Waste Form:	Polyethylene
Waste Type:	Not specified
Waste Loading:	--
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	--
Biological Stability:	--
Leach Resistance:	--
Immersion Stability:	--
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	Replaced by "Test for Solid Oxidizing Substances," for DOT use to qualify hazardous wastes.

ORGANIC BINDER SUMMARIES **NO. 45**

TITLE: Long-Term Properties of TVO's Bituminized Resins

AUTHOR: M. Valkiainen; U. Vuorinen

PUBLICATION: YJT-89-06

DATE: June 1989

ORGANIZATION: Nuclear Waste Commission of Finnish Power Companies

Waste Form:	Bitumen
Waste Type:	Spent ion-exchange resins (Nordic)
Development Status:	--
Compressive Strength:	--
Thermal Stability:	--
Radiation Stability:	In individual drums (200 l), the amount of generated radiolytic gas may be appreciable in terms of drum volume leading to possible swelling of the product and possible pressurizing of the drum.
Leach Resistance:	Leaching in cement equilibrated water with Brodersen method. Samples have been in leachant for several years. Leaching tends to increase with decreasing pH.
Immersion Stability:	Pretreating anion ion-exchange resin by drying at 140°C for 14 hours reduces rewetting and swelling capacity. Only in products with resin contents below 20%, can the resin particles be completely bitumen surrounded.
Free Liquids:	--
Chemical Durability:	--
Compositional Flexibility:	--
Gas Generation:	--
RCRA Compliance:	--
Conclusions:	--

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