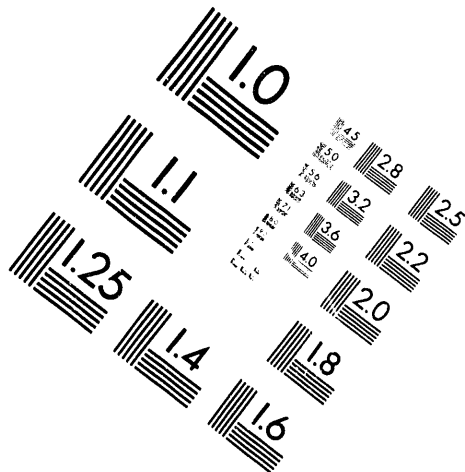
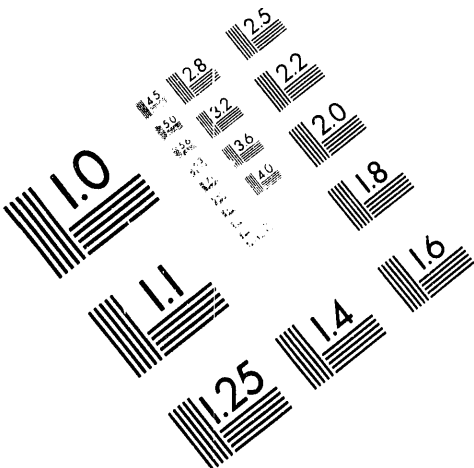




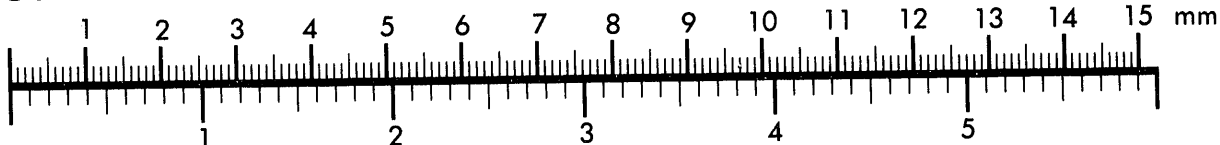
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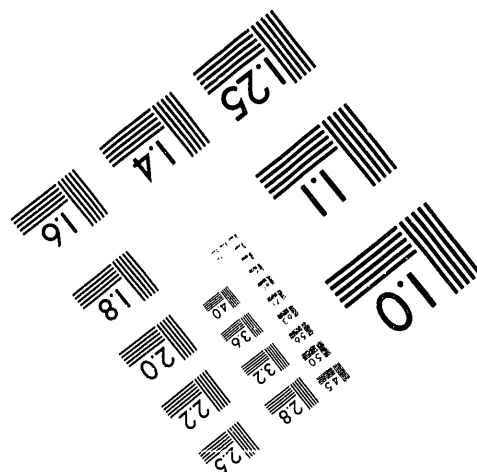
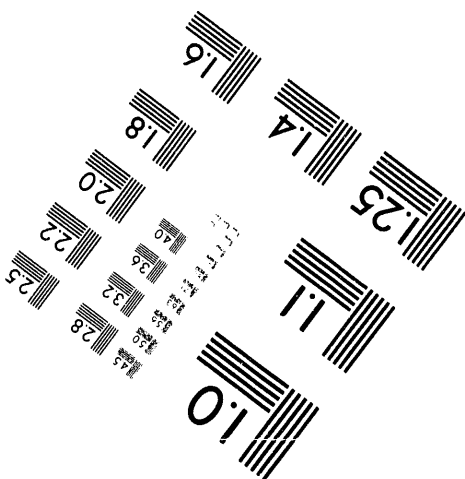
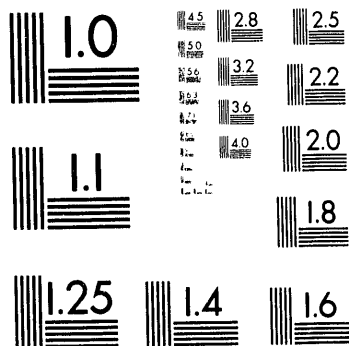
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minimization, nickel plating
line waste, incinerator wastes

**REACTIVE ADDITIVE STABILIZATION PROCESS (RASP)* FOR
HAZARDOUS AND MIXED WASTE VITRIFICATION (U)**

by

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REACTIVE ADDITIVE STABILIZATION PROCESS (RASP)* FOR HAZARDOUS AND MIXED WASTE VITRIFICATION (U)

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ABSTRACT. Solidification of hazardous/mixed wastes into glass is being examined at the Savannah River Site (SRS) for (1) nickel plating line (F006) sludges and (2) incinerator wastes. Vitrification of these wastes using high surface area additives, the Reactive Additive Stabilization Process (RASP), has been determined to greatly enhance the dissolution and retention of hazardous, mixed, and heavy metal species in glass. RASP lowers melt temperatures (typically 1050-1150°C), thereby minimizing volatility concerns during vitrification. RASP maximizes waste loading (typically 50-75 wt% on a dry oxide basis) by taking advantage of the glass forming potential of the waste. RASP vitrification thereby minimizes waste disposal volume (typically 86-97 vol. %), and maximizes cost savings. Solidification of the F006 plating line sludges containing depleted uranium has been achieved in both soda-lime-silica (SLS) and borosilicate glasses at 1150°C up to waste loadings of 75 wt%. Solidification of incinerator blowdown and mixtures of incinerator blowdown and bottom kiln ash have been achieved in SLS glass at 1150°C up to waste loadings of 50% using RASP. These waste loadings correspond to volume reductions of 86 and 94 volume %, respectively, with large associated savings in storage costs.

INTRODUCTION

Technologies are being developed by the US Department of Energy's (DOE) Nuclear Facility sites to convert low-level and mixed wastes to a solid stabilized waste form for permanent disposal. One of the alternative waste forms is vitrification. The Environmental Protection Agency (EPA) has declared vitrification the Best Demonstrated Available Technology (BDAT) for high-level radioactive waste (1) and produced a Handbook of Vitrification Technologies for Treatment of Hazardous and Radioactive Waste.(2) The DOE Office of Technology Development (OTD) has taken the position that mixed waste needs to be stabilized to the highest level reasonably possible to ensure that the resulting waste forms will meet both current and future regulatory specifications. Vitrification produces durable waste forms at volume reductions up to 97%.(3) Large reductions in volume minimize long-term storage costs making vitrification cost effective on a life cycle basis.(4) The US DOE Savannah River Site (SRS), which is operated by Westinghouse Savannah River Company (WSRC), is currently investigating vitrification for disposal of various low-level and mixed wastes(3,5). The first hazardous/mixed wastes vitrified in laboratory studies at SRS have been (1) incinerator and (2) nickel plating line (RCRA F006) wastes. Vitrification into simple glass compositions was achieved by tailoring the glass composition to take advantage of the common glass constituents-Si, Al, Na, and Ca-already in the waste. Stabilization of the heavy metals in the glass is achieved by use of reactive additives such as diatomaceous earth, perlite (perflo), rice husk ash, and/or precipitated silica. The process/product models developed for high level radioactive waste glass were utilized to develop glass formulations which optimize glass processability, e.g viscosity, and product durability (6).

* patent pending

Nickel-Plating Line Wastes

The M-Area operations at the Savannah River Site (SRS) in Aiken, South Carolina, produce reactor components for nuclear weapons materials for the U.S. Department of Energy. The resulting waste is a mixed F006 waste which is currently being stored in the Process Waste Interim Treatment/Storage Facility (PWIT/SF). The total current volume in storage was initially ~1,200,000 gallons of which ~25% is a gelatinous hydroxide sludge. There is approximately 210,000 gallons of F006 waste sludge which is high in nickel and uranium. It has been demonstrated (7) that a volume reduction of 65-70% of the M-Area waste can be achieved by wastewater treatment of the supernate, with the resulting effluent released via a NPDES outfall. About 450,000 gallons of spent SiO₂ rich filter aids (perlite/perflo) will be generated from the supernate treatment.

In January 1989 South Carolina Department of Health and Environmental Control (SCDHEC) approved a construction permit for the DETF Supernate Transfer Facility. This allowed the DETF to be used to treat the supernate from the M-Area Interim Storage/Treatment Facility (IS/TF) tanks. There are six 35,000 gallon tanks (Tanks 1-6) and three 500,000 gallon tanks (Tanks 7, 8, 10). Tanks 1-7 are full. Tank 10 is currently being filled with spent filter aid materials. Treatment of the supernate from Tank 8 was completed in November, 1992. Treatment of the supernate from Tank 7 is in progress. Treatment of the supernate in the remaining tanks will occur sequentially.

The sludge and spent filter aid wastes are to be homogenized into one batch before final stabilization/solidification. Volume reductions on the order of ~50%, were demonstrated by mixing portland cement with the sludge/spent filter aid, followed by pressure filtration and rinsing. This process has been designated FIST for Filtration and Stabilization process (7,8).

Incinerator Ash/Incinerator Blowdown Wastes

The Consolidated Incineration Facility (CIF) is a facility under construction for the U.S. Department of Energy at the Savannah River Site (SRS) in Aiken, South Carolina (9). The CIF is a rotary kiln incinerator that will thermally destroy toxic constituents and volumetrically reduce both solid and liquid waste materials. Subsequent stabilization is required to allow disposal of the wastes (9-10). The facility will handle a variety of waste types which are categorized within the classifications of low-level-radioactive, hazardous and/or mixed waste. The facilities design criteria require that operation be controlled within the limits of the Resource Conservation and Recovery Act's (RCRA) permit approved by the South Carolina Department of Health and Environmental Control (SCDHEC) (10).

The CIF is designed to allow simultaneous processing of high heat content liquid organic waste; low heat content aqueous solutions, and boxed low-level radioactive/mixed hazardous solid waste in the primary combustion rotary kiln (RK). Combustible wastes fed into the RK are volatilized, and a partially oxidized flue gas is produced. Noncombustible aqueous solutions evaporate (10-11). Flue gases from the rotary kiln enter the secondary combustion chamber (SCC) at a controlled minimum temperature of 1000°C where the kiln exit gases are processed at >1200°C to assure complete combustion and to decompose any unburned organic toxic constituents. Additional high heat content radioactive organic liquid waste is simultaneously injected into the secondary combustion chamber for destruction at >1200°C.

The CIF generates two secondary mixed waste streams that require treatment before disposal (12). The first is the rotary kiln bottom ash, a heavy ash residue produced primarily from the rotary kiln combustion but also containing materials from the secondary combustion chamber (SCC). Current plans are to solidify the accumulated ash in drums by mixing it with cement to form a stable mixture referred to as "ashcrete." The second waste stream from the CIF is the off-gas scrubbing liquor (blowdown). These liquids must be treated as radioactive process by-products. This blowdown waste contains chloride salts produced from the neutralization of acid gases and entrained flyash from the kiln. The blowdown contains approximately 80

wt% water and 20 wt% chloride salt, ash, radioactive, and hazardous contaminants that were entrained or volatilized during incineration. Liquid blowdown will be more difficult to stabilize than bottom ash because of high halide concentration, soluble heavy metals, and radionuclides.

EXPERIMENTAL

The nickel plating line waste glasses were made of actual nickel plating line sludge and spent filter aid (perlite/perflo) by adding reagent grade chemicals. Waste loadings varied from 90 to 70 wt%. The incinerator waste glasses were made from simulated ash and simulated blowdown using reagent grade chemicals and varying sources of SiO_2 , e.g. silica sand, diatomaceous earth, Perlite, or pyrolyzed rice husks. Waste loadings were varied from 30 to 50 wt% waste on a dry oxide basis. Initial glass formulations were determined by substitution of Na_2O for NaCl since simulation of dechlorination by pyrohydrolysis (13) is difficult to achieve in crucible studies. Two glasses were made with the reference amounts of NaCl and water in an attempt to pyrohydrolyze the NaCl in a crucible.

All glasses were melted at temperatures between 1150° and 1300°C in high purity Al_2O_3 crucibles for 4 hours. Small amounts of glass, ~100 gram batches, were made to optimize the best compositions for further testing.

Each vitrified sample was submitted for x-ray diffraction (XRD) analysis so that the homogeneity of the resulting glass could be determined. For glasses which were not homogeneous, the crystalline phases were identified by XRD. If analysis by XRD was inconclusive, elemental scans by x-ray fluorescence (XRF) were substituted.

A modified EPA Toxic Characteristic Leaching Procedure (TCLP) was performed at the Savannah River Technology Center on representative homogeneous glasses and one one incompletely reacted CIF simulated waste glass.

RESULTS AND DISCUSSION

Reactive Additive Stabilization Process (RASP)

Reactive high surface area silica, as a waste form additive, was determined to greatly enhance the solubility and retention of hazardous, mixed and heavy metal species in glass. Highly reactive silica was found to increase the solubility and tolerance of Soda(Na_2O)-Lime(CaO)-Silica(SiO_2) glass (SLS) and borosilicate (B_2O_3 - SiO_2) glass formulations to atomistically bond the waste species. Highly reactive silica lowers glassification temperatures, increases waste loadings which provides for large waste volume reductions, and produces EPA acceptable glasses. The Reactive Additive Stabilization Process (RASP) can be used to vitrify (1) spent filter aids from wastewater treatment, (2) waste sludges, (3) combinations of spent filter aids from wastewater treatment and waste sludges, (4) combinations of supernate and waste sludges, (5) incinerator ash, (6) incinerator off-gas blowdown, (7) combinations of incinerator ash and off-gas blowdown, (8) cement formulations in need of remediation into glass, (9) ion exchange zeolites, (10) inorganic filter media, (11) asbestos or glass fiber filters, and (12) radioactive materials including TRU wastes.

Nickel-Plating Line Glasses

The M-Area nickel plating line waste sludges plus the spent filter aid from the associated supernate treatment are examples of RASP stabilization. Representative samples of the RCRA F006 sludge in each of the M-area tanks, including the tank with the spent filter aid, was analyzed between 1987 and 1993. X-ray diffraction analysis of the sludges dried at 90°, 300°, and 600°C allowed the chemical phases to be identified and a molar mass balance calculation to be performed (Table 1). The aluminum is present primarily as Al(OH)₃, while the Na is present as NaNO₃. Using the current and projected tank volume inventories a calculated composite waste composition based on a dry calcine basis was determined (Table 1).

Table 1. M-Area Calculated Composite Sludge Composition.*

<u>Oxide Wt%</u>		<u>Oxide Wt%</u>		<u>Mass Balance Speciation Wt% **</u>	
Al ₂ O ₃	17.47	TiO ₂	0.04	Al(OH) ₃	23.18
CaO	0.48	K ₂ O	1.48	NaNO ₃	17.88
Fe ₂ O ₃	0.88	P ₂ O ₅	3.22	SiO ₂	43.44
MgO	0.20	BaO	0.02	Na ₆ U ₇ O ₂₄	3.48
MnO	0.28	PbO	0.11	Ca-zeolite	3.15
Na ₂ O	10.83	MoO ₃	0.01	AlPO ₄	<u>4.32</u>
NiO	0.93	ZnO	0.59	SUM	95.44
SiO ₂	43.58	CuO	0.03		
Cr ₂ O ₃	0.01	SO ₄	0.03		
B ₂ O ₃	0.03	NO ₃	<u>13.05</u>		
UO ₂	3.00	SUMS	96.28		

* Current inventory plus additional filter aid projected from continued supernate treatment

** Species identified by x-ray diffraction analysis

The high SiO₂, Al₂O₃ and Na₂O content of the M-Area waste indicated that stabilization in either sodium borosilicate or SLS glass was feasible. The addition of only one additive, B₂O₃, borax (Na₂O•2B₂O₃•10H₂O), or Na₂O•B₂O₃ enabled the waste mixture to be made into a borosilicate glass (Figure 1, Table 2) while the addition of only CaCO₃ or a mixture of CaCO₃ and Na₂CO₃ allowed solidification into SLS glass (Figure 2, Table 2). The use of only one additive simplifies processability of the waste as only two components need to be adjusted in order to optimize processability and waste loading (Figure 1).

Vitrification was achieved in both borosilicate and SLS glass at waste loadings varying between 70 to 90 wt% waste (Table 2). Higher waste loadings were achieved at higher melt temperatures. Homogeneous glasses formed at 1150°C at waste loadings of 70 to 80 wt%. The borosilicate system is a well known glass forming system used to make commercial pyrex and vycor glasses which are very stable but are phase separated. Many types of high-level radioactive wastes are being solidified in borosilicate glasses which are in the known glass forming region of the Na₂O-B₂O₃-SiO₂ system, but away from the known region of phase separation (14). Phase separation is undesirable for waste stabilization because phase separated glasses tend to be less durable than homogeneous glasses (15).

Table 2. Glass Formulations and Additives for M-Area Sludge with Spent Filter Aid

Glass	Waste Wt%*	Melt Temp. (°C)	Type of Additive	Type of Glass	Results
M-1	90	>1300	Borax	Borosilicate	Poorly Melted
M-2	85	>1300	Borax	Borosilicate	Poorly Melted
M-3	90	>1300	H ₃ BO ₃	Borosilicate	Poorly Melted
M-4	90	>1300	CaCO ₃	SLS	Poorly melted
M-5	80	>1250	H ₃ BO ₃ + Na ₂ CO ₃	Borosilicate	Poorly melted
M-6	70	1150	Borax + Na ₂ CO ₃	Borosilicate	Homogeneous Glass
M-7	80	>1150	CaCO ₃ + Na ₂ CO ₃	SLS	Poorly melted
M-8	70	1150	Borax	Borosilicate	Homogeneous Glass
M-9	70	1150	CaCO ₃ + Na ₂ CO ₃	SLS	Homogeneous Glass

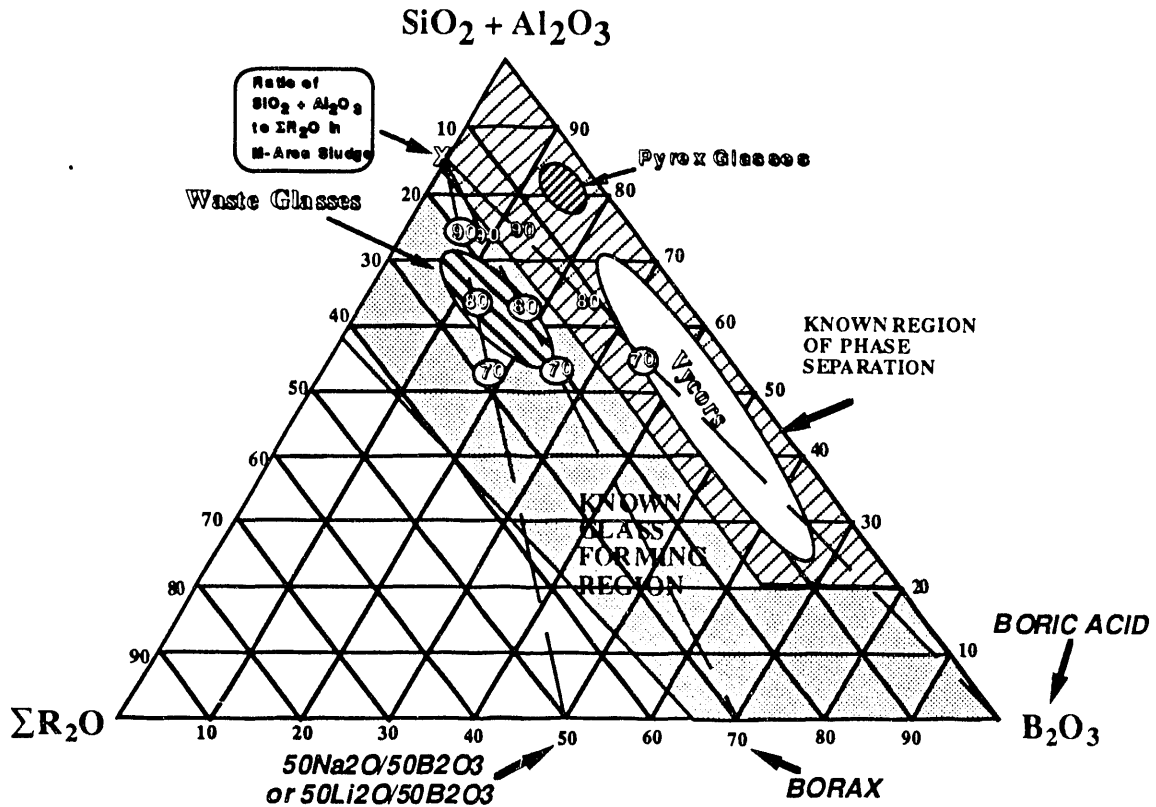


Figure 1. Ternary phase diagram for the system Na₂O-B₂O₃-SiO₂ with the glasses formulated for M-Area sludges superimposed (wt%). The "X" indicates the ratio of SiO₂ + Al₂O₃ to the alkali oxides (R₂O) in the M-Area sludge and filter aid. The stippled area indicates the known glass forming region in the Na₂O-B₂O₃-SiO₂ system. The cross hatched area indicates the known region of phase separation and includes the commercial pyrex and vycor glasses. Glasses in the region of phase separation tend to be less durable than glasses in the other region of the Na₂O-B₂O₃-SiO₂ system.

To date the TCLP leaching procedure has been performed on one borosilicate glass (M-6) and one SLS glass (M-9). Both of these glass formulations contained 70 wt% waste on a dry basis (Table 1). Both glass formulations had melted to a homogeneous glass at 1150°C. Both glasses passed the TCLP leachate limits for Pb, Ba, and Cr. The borosilicate glass formulation was superior to the SLS glass formulation for retention of Ni and U (Table 3). The SLS glass (M-9) did not meet the Land Disposal Restrictions for Ni but the borosilicate glass (M-6) did.

Table 3. Toxic Characteristic Leaching Procedure (TCLP) and Land Disposal Restriction (LDR) Limits and Response for M-Area Glasses.

Element	Wt%	Wt% Glass	Wt% Glass	Waste Code	LDR Limit (ppm)*	TCLP Leachate	
	Sludge	M-6 ^t	M-9 ^t			M-6	M-9
Pb	0.10	0.074	0.074	F006	0.51	<0.2	<0.2
Ba	0.018	0.013	0.013	N/A	100	1.85	1.40
Ni	0.73	0.51	0.51	F006	0.32	0.17	0.74
Cr	0.007	0.005	0.005	F006	5.2	<0.04	<0.04
U	2.65	1.85	1.85	N/A	N/A	0.10	0.45

^t M-6 and M-9 contained 70 wt% waste on a calcine oxide basis

* 40 CFR 148, et. al., Land Disposal Restriction for Third Third Scheduled Wastes Final Rule, 55 FR 22 250, June 1, 1990.

Incinerator Ash/Incinerator Blowdown Glasses

Reactive silica was added to the CIF incinerator wastes as the only glass forming additive. Mixtures of silica with CIF blowdown and mixtures of silica with CIF blowdown and bottom kiln ash are examples of RASP stabilization. A simulated waste formulation for both the ash and the blowdown indicated that the blowdown was high in Na while the bottom kiln ash was high in Ca and Zn. The high Na₂O and CaO content of this waste indicated that stabilization in SLS glass was feasible by addition of only one additive, SiO₂. The use of only one additive simplifies processability of the waste as only two components need to be adjusted in order to optimize processability and waste loading. All vitrification was conducted at 1150°C to minimize volatility of chlorides and radioactive Cs which will be present.

A waste loading of 45-50 wt% (on a dry oxide basis), which corresponds to a volume reduction of 94%, was demonstrated for solidification of CIF blowdown in soda-lime-silica (SLS) glass. The use of reactive SiO₂ additives in the form of precipitated SiO₂, Perlite (Perflo), diatomaceous earth, and pyrolyzed rice husk ash were shown to improve the solubility of the hazardous and heavy metal constituents in the glass (Table 4). The glasses made with Perlite and diatomaceous earth were easier to fabricate and poured more easily at 1150°C than the glasses made with precipitated SiO₂ and rice husk ash. Mixtures of incinerator blowdown and bottom kiln ash, at known production ratios, were also vitrified (Table 4). Changes in the composition of the CIF wastes can be easily compensated for by adjusting the ratio of the SiO₂ additive to the amount of waste (Figure 3). The SLS glass was shown to be tolerant of a wide range of variability in the waste composition (Table 4). The high ZnO content of the waste, especially of the bottom kiln ash, stabilizes the glass against crystallization and is known to improve glass durability. For the CIF wastes, Figure 3 demonstrates that the use of reactive silica, in this case the spent filter aid already a part of the waste, extends the known glass forming region in the SLS system.

Table 4. Glass Formulations and Additives for CIF Blowdown and CIF Blowdown with Bottom Kiln Ash at 1150°C.

Glass	Waste Loading (wt%)	Amount of Blowdown* (wt%)	Amount of Kiln Ash (wt%)	Type of Additive	Additive Amount (wt%)	Results
CIF-1	50	50	0	SiO ₂ **	50	Yellow Phase
CIF-2	33	33	0	SiO ₂	67	Yellow Phase
CIF-3	30	30	0	SiO ₂	70	Yellow Phase
CIF-4	45	45	0	DIATOM EARTH	55	Homogeneous
CIF-5	45	45	0	PERLITE	55	Homogeneous
CIF-6	45	45	0	SiO ₂	55	Yellow Phase
CIF-7	50	34	16	SiO ₂	50	Yellow Phase
CIF-8	50	50	0	Borosilicate Frit 165	50	Some Cu hydroscopic
CIF-9	45	45	0	PPT SiO ₂	55	Homogeneous
CIF-10	50	34	16	DIATOM EARTH	50	Homogeneous
CIF-11	50	34	16	PERLITE	50	Homogeneous
CIF-12	50	34	16	PPT SiO ₂	50	Homogeneous
CIF-13	50	50	0	DIATOM EARTH	50	Homogeneous
CIF-14	50	50	0	PPT SiO ₂	50	Homogeneous would not pour
CIF-15	33	33	0	PPT SiO ₂	67	Homogeneous would not pour
CIF-16	30	30	0	PPT SiO ₂	70	Homogeneous would not pour
CIF-17	50	34	16	DIATOM EARTH	50	NaCl-incomplete reaction in 4 hrs.
CIF-18	50	50	0	DIATOM EARTH	50	NaCl-incomplete reaction in 4 hrs.
CIF-19	50	50	0	RICE HUSK SiO ₂	50	Did not melt until 1200°C
CIF-20	34+16	34	16	RICE HUSK SiO ₂	50	Did not melt until 1200°C

* on a dry weight oxide basis

**SiO₂ refers to granular SiO₂

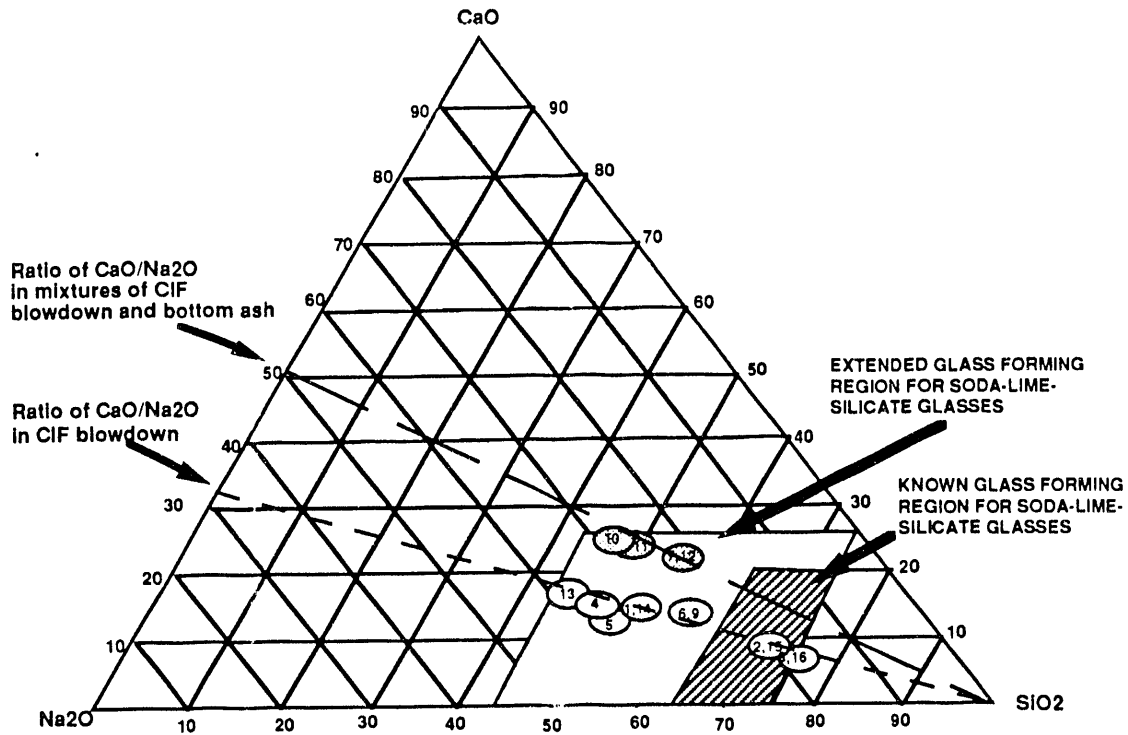


Figure 3. Ternary phase diagram for the system $\text{Na}_2\text{O}-\text{CaO}-\text{SiO}_2$ system with glasses formulated for the CIF wastes superimposed (wt%). The cross hatched parallelogram represents the known glass forming region in this system while the larger shaded parallelogram represents the extended glass forming region determined in this study by use of reactive silica additives.

The SRTC modified EPA TCLP leaching procedure was performed on three homogeneous CIF SLS glasses (CIF-10, 13, 14) and on one of the incompletely reacted CIF SLS glasses (CIF-17). Glasses CIF-10 and CIF-17 were vitrified with diatomaceous earth. Both contained mixtures of CIF blowdown and ash at a total waste loading of 50 wt%. Glasses CIF-13 and CIF-14 were vitrified with diatomaceous earth and precipitated SiO_2 , respectively. Both were fabricated from 50 wt% dry calcined blowdown. All of the glasses met the LDR leachate limits for Pb, Ba, and Ni. The glasses made with diatomaceous earth stabilized the Cr at LDR limits lower than those required for D007 and F006 wastes but not for U032 wastes. The glass made with precipitated SiO_2 met all the LDR limits.

WASTE MINIMIZATION

Wastewater treatment of M-Area supernate reduces the 1,200,000 gallon volume of the M-Area sludge + supernate by 65-70 volume % leaving 210,000 gallons of sludge and 450,000 gallons of newly created spent filter aid. The 210,000 gallons of sludge is approximately 38 wt% dry solids with NO_3 accounting for 4 wt%, at a density of 1.26 kg/L. Evaporation of the NO_3 during vitrification would, therefore leave ~34 dry wt% sludge solids remaining for incorporation into glass. The 450,000 gallons of spent filter aid is 17 wt% solids with a density of 1.1 kg/L. Assuming a 75 wt% waste loading, the combined 650,000 gallons of sludge and spent filter aid can be solidified into ~92,000 gallons of glass. This is a sludge/spent filter aid waste volume reduction of ~86% assuming a glass density of 2.7 kg/L for the final glass. Similarly, a 90 wt% waste loading will yield 75,000 gallons of glass and result in an overall waste volume reduction of ~88 volume %.

Table 5. Toxic Characteristic Leaching Procedure (TCLP) and Land Disposal Restriction (LDR) Limits and Response for CIF Glasses.

CONCENTRATIONS OF HAZARDOUS COMPOUNDS IN THE WASTE GLASS

Element	Wt% Blow Down	Wt% Ash	Wt% Diatom Earth*	Wt% Glass CIF-10**	Wt% Glass CIF-13 ^{tt}	Wt% Glass CIF-14 ^{tt}	Wt% Glass CIF-17**
Pb	0.19	0.46	0.18	0.23	0.05 ^t	0.09	0.03 ^t
Ba	0.09	0.22	0.03	0.08	0.06 ^t	0.04	0.08 ^t
Ni	0.00	0.00	0.24	0.13	0.13	0.00	0.13
Cr	0.07	0.17	0.00	0.05	0.03 ^t	0.03	0.04 ^t

* Diatomaceous earth used as a glass forming additive for CIF-10, CIF-13 and CIF-17, precipitated silica used as a glass forming additive for CIF-14

** CIF-10 and CIF-17 contained 16 wt% bottom ash and 34 wt% dry blowdown on a calcine oxide basis
t measured by Inductively Coupled Plasma Spectroscopy

tt CIF-13 and -14 contained 50 wt% dry blowdown on a calcine oxide basis

TCLP LEACH TEST RESPONSE OF CIF WASTE GLASSES

Element	Waste Code	LDR Limit* (ppm)	CIF-10 Leach (ppm)	CIF-13 Leach (ppm)	CIF-14 Leach (ppm)	CIF-17 Leach (ppm)
Pb	D008	5.0	<0.2	<0.2	<0.2	<0.2
	U051	0.51				
	F006	0.51				
Ba	D005	100	2.2	2.3	2.2	5.12
Ni	F006	0.32	0.15	0.072	N/A ^t	<0.05
Cr	D007	5.0	0.93	0.68	<0.04	0.69
	U032	0.094				
	F006	5.2				

* 40 CFR 148, et. al., Land Disposal Restriction for Third Third Scheduled Wastes Final Rule, 55 FR 22 250, June 1, 1990.

t not applicable since no Ni was present in the CIF-14 glass which was made with precipitated silica rather than diatomaceous earth

Comparisons of the overall waste volume reduction compared to alternative stabilization strategies in cement (Table 6) shows that vitrification of M-Area sludge and spent filter aid (Option 3) reduces the stabilized volume by 96% relative to the base case cement stabilization where both supernate and sludge would have to be stabilized. Vitrification of wastewater treated sludge and spent filter aid (Option 3) reduces stabilized volume by an additional 50 volume % relative to Option 1 (cement stabilization of wastewater treated sludge and spent filter aid) and by an additional 10 volume % relative to Option 2 (FIST (FIltration and STabilization) stabilization (7,8) in cement).

Table 6. Comparative Volume Reductions for M-Area Waste Stabilization.

<u>Stabilization Options</u>	<u>Volume Reduction*</u>
<u>Base Case (CEMENT WITH SUPERNATE)</u> 1,200,000 gallons of M-Area supernate + sludge = 2,400,000 gallons cement	0%
<u>Option 1 (CEMENT WITHOUT SUPERNATE)</u> 650,000 gallons sludge + spent filter aid + cement = 1,300,000 gallons cement	46%
<u>Option 2 (FIST)</u> 650,000 gallons wastewater treated sludge/spent filter aid + cement = 325,000 gallons cement	86%
<u>Option 3 (RASP)**</u> 650,000 gallons wastewater treated sludge + spent filter aid = 92,000 gallons glass	96%

* Relative to original 2,400,000 gallons grout projected if the sludge is not wastewater treated

** assumes the glass is 75wt% waste on a dry calcine basis

The Consolidated Incinerator Facility (CIF) will create approximately 250,000 gallons of blowdown per year. Eighty-five percent of the blowdown is water and 10 wt% is NaCl solids and ash residue. Some of the anionic constituents, such as Cl are volatile leaving ~8wt% solids to be solidified. A 50 wt% waste loaded SLS glass could be formed from CIF blowdown by adding ~8 wt% SiO₂ to the calculated 8 wt% blowdown residue on a dry basis. Assuming a 50% waste loading and a glass density of 2.7 g/cc, one can project that 250,000 gallons of CIF waste slurry a year will produce ~ 15,000 gallons of glass per year. Stabilization of the CIF blowdown in a 50% waste loaded glass will yield a 94% volume reduction. The base case stabilization methodology for the CIF blowdown is to immobilize the untreated blowdown in cement. This base case methodology would create a projected 500,000 gallons of cement per year (Table 7). If the CIF blowdown were wastewater treated prior to cement stabilization, 100,000 gallons of cement would be created per year (Option 1). If the CIF blowdown is evaporated to dryness and then solidified in cement, asphalt, bitumen, polymer, etc., 60,000 gallons of stabilized sodium salt and ash solids containing organics would be created (Option 2). Vitrification would create only 15,000 gallons of glass (Option 3).

Comparison of vitrification of CIF blowdown to the alternative stabilization in concrete (Table 7) demonstrates that a 97% volume reduction can be realized compared to stabilization of unevaporated blowdown in concrete (Base Case). An additional 17% volume reduction can be achieved compared to the alternative of wastewater treatment coupled with cement stabilization (Option 1), and a 9% reduction compared to the alternative of evaporation and stabilization (Option 2).

Table 7. Comparative Volume Reductions for CIF Blowdown Waste Stabilization in Glass Compared to Cement Stabilization, Wastewater Treatment/Stabilization, and Evaporation/Stabilization.

<u>Stabilization Options</u>	<u>Volume Reduction/year*</u>
<u>Base Case</u>	
250,000 gallons/year of CIF blowdown + cement = 500,000 gallons cement/year	0%
<u>Option 1</u>	
50,000 gallons wastewater treated CIF blowdown + cement = 100,000 gallons cement/year	80%
<u>Option 2</u>	
30,000 gallons CIF blowdown evaporated to dryness + thermoplastic resin = 60,000 gallons stabilized evaporate/year	88%
<u>Option 3 (RASP)</u>	
250,000 gallons CIF blowdown = 15,000 gallons glass/year	97%

* Relative to original 500,000 gallons grout/year projected for the base case

CONCLUSIONS

Laboratory scale studies have demonstrated that vitrification of hazardous/mixed wastes at the Savannah River Site is viable for (1) nickel plating line (F006) sludges and (2) incinerator wastes. Vitrification of these wastes using high surface area additives, the Reactive Additive Stabilization Process (RASP), was shown to enhance the dissolution and retention of hazardous, mixed, and heavy metal species in glass. Vitrification has been achieved in both soda-lime-silica (SLS) and borosilicate glasses at waste loadings from 50 (CIF wastes) to 90 (sludge wastes) wt%. These waste loadings correspond to volume reductions of 94% and 86%, respectively, with large associated savings in storage costs.

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