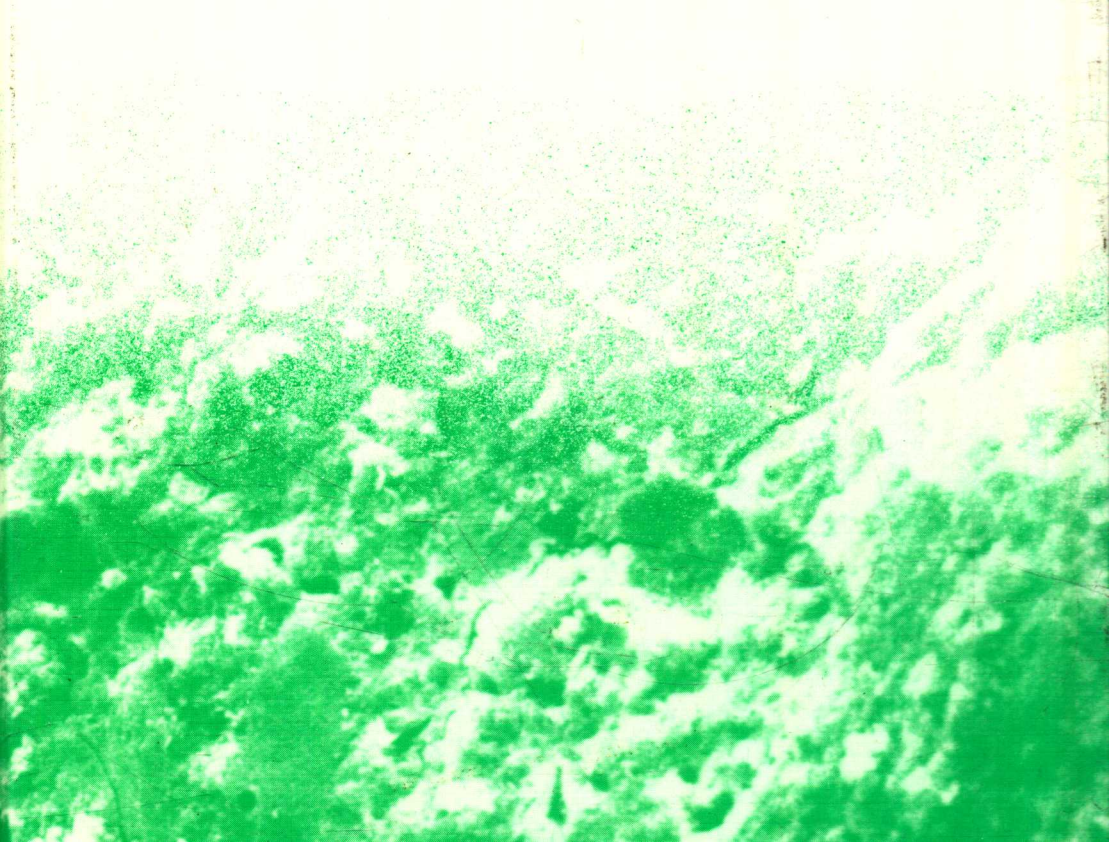


Volume 23

C*eramic*
T*ransactions*

NUCLEAR WASTE
MANAGEMENT IV

George G. Wicks • Dennis F. Bickford • L. Roy Bunnell



Volume 23

**Ceramic
Transactions**

**NUCLEAR WASTE
MANAGEMENT IV**

Edited by George G. Wicks and Dennis F. Bickford,
Westinghouse Savannah River Co., and
L. Roy Bunnell, Pacific Northwest
Laboratory

The American Ceramic Society, Inc.
Westerville, Ohio

Proceedings of the Fifth International Symposium on Ceramics in Nuclear and Hazardous Waste Management held during the 93rd Annual Meeting of The American Ceramic Society in Cincinnati, Ohio, April 29–May 3, 1991.

Library of Congress Cataloging-in-Publication Data

International Symposium on Ceramics in Nuclear and Hazardous Waste Management (5th : 1991 : Cincinnati, Ohio)

Nuclear waste management IV / edited by George G. Wicks, Dennis F. Bickford, and L. Roy Bunnell.

p. cm—(Ceramic transactions ; v. 23)

“Proceedings of the Fifth International Symposium on Ceramics in Nuclear and Hazardous Waste Management held during the 93rd Annual Meeting of the American Ceramic Society in Cincinnati, Ohio, April 29–May 3, 1991”—T.P. verso.

Includes index.

ISBN 0-944904-45-9

1. Radioactive waste disposal—United States—Congresses. 2. Radioactive waste disposal—New York (State)—West Valley—Congresses. 3. Glass waste—Environmental aspects—United States—Congresses. 4. Ceramics—Congresses. I. Wicks, George G. II. Bickford, D.F. (Dennis F.) III. Bunnell, L.R., 1943–. IV. American Ceramic Society. Meeting (93rd : 1991 : Cincinnati, Ohio) V. Title. VI. Title: Nuclear waste management 4. VII. Title: Nuclear waste management four. VIII. Series.

TD898.118.I57 1991

621.48'38—dc20

91-34194

CIP

Copyright © 1991, The American Ceramic Society, Inc. All rights reserved.

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the publisher.

Printed in the United States of America

1 2 3-4-95 94 93 92 91

ISBN 0-944904-45-9

Preface

In 1991, the American Ceramic Society was pleased to sponsor the fifth in a series of international symposia on nuclear waste management activities. The Fifth International Symposium on Ceramics in Nuclear and Hazardous Waste Management was held April 28–May 2 in Cincinnati, Ohio, as part of the 93rd Annual Meeting of the Society. The symposium was organized by the Nuclear Division of The American Ceramic Society, in cooperation with the Glass and Optical Materials, Cements, and Engineering Ceramics Divisions.

The symposium highlighted many interesting areas of waste management and emphasized engineering aspects of waste immobilization. Special emphases were placed on glass melting and processing, waste form process controls, and product qualifications. During the three-day symposium, 75 papers were presented in ten technical sessions. These sessions included HLW Program Overviews/Waste Form Characterization, Chemical Durability of Waste Forms and Products, Cementitious Waste Forms, Glass Melting and Processing—Chemical Considerations, Glass Melting and Processing—Melters, Microwave Applications in Waste Management, Waste Form Qualifications, Decontamination Studies, Waste Form Process Controls, and In Situ Vitrification/Repository Relevant and Field Testing of Waste Forms.

Participants at the symposium came from a variety of countries and organizations and included representatives from academia; federal, national, and international laboratories; governmental organizations; and industry. The organizers are grateful to their colleagues who participated in this effort and especially to those who chaired sessions and reviewed the many manuscripts for these proceedings. Included are S.O. Bates, M.K. Choudhary, D.E. Clark, K.B. Harvey, P.R. Hrma, V. Jain, C.M. Jantzen, C.A. Langton, R.A. Palmer, M.J. Plodinec, W.A. Ross, A.K. Sakar, and H.D. Schreiber. The organizers would also like to thank the U.S. Department of Energy for their support in publishing the symposium proceedings and The American Ceramic Society for their considerable time and help in this effort.

The symposium co-chairs would like to give a very special thanks and acknowledgement to Laura Jordan, who was Administrative Assistant for this entire effort. Without her help, the symposium would not have run as smoothly as it did, and the organization and quality of these proceedings are a reflection of her hard work and dedication.

George G. Wicks
Dennis F. Bickford
L. Roy Bunnell

Ceramic Transactions is a new proceedings series designed to meet two needs: high quality content and rapid publication. Volumes in the series come from meetings, symposia, and forums. Each paper is reviewed by two peers, and final manuscripts are prepared by authors in a "camera-ready" format. The volumes in this series would not be possible without the hard work, dedication, and cooperation of editors, reviewers, and authors, who all deserve a great deal of thanks.

Your comments, questions, and suggestions for future *Ceramic Transactions* volumes are welcomed and should be addressed to the Director of Publications, The American Ceramic Society, Inc.

Contents

Section I. HLW Program Overviews/ Waste Form Characterization

Savannah River Site High-Level Waste Program and the Defense Waste Processing Facility	3
W. D. Pearson	
West Valley Demonstration Project—Current Progress and Status	11
W.S. Ketola	
Characterization and Vitrification of Hanford Radioactive High-Level Waste	15
J.M. Tingey, M.L. Elliot, D.E. Larson, and E.V. Morrey	
Effects of HIPing Time, Temperature, and Pressure on Experimental ICPP Waste Form Properties	27
B.A. Staples and D.V. Miley	
First Principles Process-Product Models for Vitrification of Nuclear Waste: Relationship of Glass Composition to Glass Viscosity, Resistivity, Liquidus Temperature, and Durability	37
C.M. Jantzen	
Results of Vitrifying Fernald K-65 Residue	53
D.S. Janke, C.C. Chapman, and R.A. Vogel	

Section II. Chemical Durability of Waste Forms and Products

Identification of Colloids in Nuclear Waste Glass Reactions	65
J.C. Cunnane and J.K. Bates	
Secondary Lead Smelter Slags: Minimizing Lead Release Levels	75
E.S. Shenkler, S. Graham, and V.A. Greenhut	

Redox State Effects on Microstructure and Leaching Properties of West Valley SF-12 Glass	85
A.C. Buechele, X. Feng, H. Gu, and I.L. Pegg	
Effects of pH on the Leaching Mechanism of Nuclear Waste Glasses	95
X. Feng, I.L. Pegg, Q. Yan, X. Mao, and P.B. Macedo	
Predictive Modeling of Leachate pH for Simulated High-Level Waste Glass	105
W.G. Ramsey, T.D. Taylor, and C.M. Jantzen	
In Situ Zeta Potential Measurements of Simulated Nuclear Waste Glass Using Electrokinetic Sonic Amplitude Techniques	115
R.L. Schulz, B.K. Zoitos, D.E. Clark, and G.G. Wicks	
The Dissolution of a Single Specimen of a Simple Glass	123
K.B. Harvey, C.A.B. Larocque, S. Watson, and D.C. Doern	
Solution Chemistry of Noble Metals in a Model Nuclear Waste Glass	135
H.D. Schreiber, M.W. Riethmiller, and T.P. Duggan	

Section III. Cementitious Waste Forms

Grout-Based Waste Forms for the Solidification of Anion Exchange Resins	147
W.D. Bostick, P.E. Osborne, G.D. Del Cul, and I.L. Morgan	
Characterization of Hydration Sensitive Stabilized Ion-Exchange Resins	157
H.M. Henson, D.P. Hoffmann, R.C. Melton, R.S. Sherles, M.A. Schmidt, G.C. Marsh, and M.J. Bridges	
A Study of Concrete for the Tumulus Disposal Units in Low-Level Radioactive Waste Management	171
J.H. Lee, D.M. Roy, P.H. Licastro, and B.E. Scheetz	
Reduction in Nitrate Leaching from a Cement Wasteform by Using Waterproofing Admixture Additions	181
M.D. Kass and H.G. Lefort	

Properties of Slag Concrete for Low-Level Waste Containment	191
C.A. Langton and P.B. Wong	
Analysis of the Physical and Chemical Aspects of Leaching Behavior in Lead- and Chromium-Doped Portland Cement Wasteforms	201
R.C. Davis and D.L. Cocke	

Section IV. Glass Melting and Processing —Chemical Considerations

Solubilities of Nickel and Cobalt Chalcogenides in a Nuclear Waste Glass Melt	213
H.D. Schreiber, E.D. Sisk, C.W. Schreiber, and J.K. Burns	
Evaluation of Vitrifying Municipal Incinerator Ash	223
C.C. Chapman	
Behavior of RuO₂ in a Glass Melt	233
W.T. Cobb and P. Hrma	
Effect of Glass Pour Cycle on the Crystallization Behavior in the Canistered Product at the West Valley Demonstration Project	239
V. Jain and S.M. Barnes	
Effect of Redox Ratio on the Crystallization Behavior in the Canistered Product at the West Valley Demonstration Project	251
V. Jain and S.M. Barnes	
Redox Analyses of SRS Melter Feed Slurry; Interactions Between Nitrate, Formate, and Phenol Based Dopants	259
W.G. Ramsey, C.M. Jantzen, and D.F. Bickford	
Control of High-Level Radioactive Waste-Glass Melters—Part 5: Modeling of Complex Redox Effects	267
D.F. Bickford and A.S. Choi	
Noble Metal Catalyzed Formic Acid Decomposition and Formic Acid Denitration	283
D.F. Bickford, C.J. Coleman, C-L.W. Hsu, and R.E. Eibling	

Immobilization of Simulated High-Level Radioactive Waste in Borosilicate Glass: Pilot Scale Demonstrations	295
J.A. Ritter, N.D. Hutson, J.R. Zamecnik, and J.T. Carter	
Stir Melter™ Vitrification of Simulated Radioactive Waste, Fiber Glass Scrap, and Municipal Waste Combustor Fly Ash	309
R.S. Richards and J.W. Lacksonen	
Recycle Stream Impacts on Feed Treatment Flowsheets and Glass Formulation for the Hanford Waste Vitrification Plant	321
R.A. Watrous, O.L. Kruger, P. Hrma, and J.M. Perez, Jr.	

Section V. Glass Melting and Processing —Melters

Advanced Radioactive Waste-Glass Melters	335
D.F. Bickford	
The Effect of Slurry Rheology on Melter Cold Cap Formation	349
D.D. Yasuda and P. Hrma	
Drainage of Primary Melt in a Glass Batch	361
P. Hrma, C.E. Goles, and D.D. Yasuda	
Fundamental Aspects of Electric Melting of Glass	369
M.K. Choudhary	
Mathematical Modeling of Radioactive Waste Glass Melter . .	385
I.G. Choi	
Computer Modeling of Ceramic Melters to Assess Impacts of Process and Design Variables on Performance	395
L.L. Eyler, M.L. Elliott, D.L. Lessor, and P.S. Lowery	
Results of a Pilot-Scale Melter Test to Attain Higher Production Rates	409
M.L. Elliott, J.M. Perez, Jr., and C.C. Chapman	
Testing of the Melter Lid Refractory for the West Valley Demonstration Project (WVDP)	419
A. Gupta, V. Jain, J.L. Mahoney, and T.M. Holman	

Section VI. Waste Form Qualifications

Waste Acceptance for Vitrified High-Level Waste Forms	433
D. Stahl and M.O. Cloninger	
The DWPF Strategy for Producing an Acceptable Product . . .	443
W.T. Goldston and M.J. Plodinec	
DWPF Batch 1, Waste Glass Investigations	453
R.F. Schumacher	
DWPF Glass Transition Temperatures—What They Are and Why They Are Important	465
S.L. Marra, C.M. Jantzen, and A.A. Ramsey	
West Valley Strategy for Meeting Waste Acceptance Preliminary Specifications	475
R.A. Palmer	
Evaluation of the Potential for Gas Pressurization and Free Liquid Accumulation in a Canister from the West Valley Demonstration Project	491
R.F. Hazelton, C.K. Thornhill, and W.A. Ross	
Effect of Redox State on the Chemical Durability of West Valley Glasses	501
X. Feng, I.S. Muller, I.L. Pegg, P.B. Macedo, J. Sehgal, I. Joseph, and L.D. Pye	
Some High Temperature Properties of Simulated West Valley Nuclear Waste Glass	509
W.C. Eaton, I. Joseph, and L.D. Pye	

Section VII. Decontamination Studies

Evaluation of Remote Smearing of DWPF Canistered Waste Forms	521
C.H. Payne and W.N. Rankin	
Surface Decontamination Using a Teleoperated Vehicle and Kelly Spray/Vacuum System	529
W.T. Zollinger and G.M. Dyches	
Foam as a Decon Waste Minimization Tool	537
K.D. Peterson, J.F. McGlynn, and W.N. Rankin	

Evaluation of the Effectiveness of the Turco Low Profile Turbulator® for Water-Bath Decontamination	543
J.R. Long, S. Grittmann, J.F. McGlynn, and W.N. Rankin	
Soluble, Vitreous Ceramic Coatings for Decontaminating Stainless Steel Canisters Filled with Radioactive Glass	551
H.G. Lefort, C.L. Selby, and J.R. Price	

Section VIII. Waste Form Process Controls

The DWPF Product Composition Control System at Savannah River: Statistical Process Control Algorithm	559
R.L. Postles and K.G. Brown	
Initial Demonstration of the DWPF Vitrification Process and Product Control Strategy Using Actual Radioactive Waste	569
M.K. Andrews, N.E. Bibler, C.M. Jantzen, and D.C. Beam	
Fabrication, Characterization, and Evaluation of a Fully Radioactive Glass Using Commercial Nuclear Waste from the West Valley Demonstration Project	577
K.M. Olson, M.L. Elliot, J.W. Shade, and H.D. Smith	
Statistical Analysis of the DWPF Prototypic Sampler	587
R.L. Postles, C.P. Reeve, W.J. Jenkins, and D.F. Bickford	
Control of High-Level Radioactive Waste-Glass Melters—Part 4: Preliminary Analysis of DWPF Process Laboratory Capabilities	597
D.F. Bickford and C.J. Coleman	
Waste Glass Structures, Basicity, and Sensors for Glass Quality Monitoring	607
D.F. Bickford	
Glass Melter Off-Gas System Pluggages: Cause, Significance, and Remediation	621
C.M. Jantzen	

Section IX. In Situ Vitrification/Repository Relevant and Field Testing of Waste Forms

In Situ Vitrification of Buried Waste Sites	633
J.W. Shade, L.E. Thompson, and C.H. Kindle	
A Product Evaluation Strategy for the Evaluation of In Situ Vitrification Waste Forms	641
S.O. Bates	
Surface Analyses of SRS Waste Glass Buried for up to Two Years in Limestone in the United Kingdom	653
C.G. Namboodri, Jr., S.L. Namboodri, G.G. Wicks, A.R. Lodding, L.L. Hench, D.E. Clark, and R.G. Newton	
Analyses of SRS Waste Glass Buried in Granite in Sweden and Salt in the United States	663
J.P. Williams, G.G. Wicks, D.E. Clark, and A.R. Lodding	
Corrosion of the Borosilicate Glass R7T7 in a Concentrated NaCl Brine—Experimental Data and Surface Characterization	675
H. Roggendorf	
Durability Study of Sodium Borosilicate Glasses Leached in Tuff J-13 Groundwater	685
W.G. Ramsey, T.D. Taylor, and C.M. Jantzen	
The Effect of Igneous Rock Type on Nuclear Waste Siting ...	695
V.J. Grassi, G.C. Ulmer, and D.E. Grandstaff	
Radioactivity of DWPF Waste Glass Compared to Natural Uranium Ore	707
J.A. Tacca and G.G. Wicks	
WIPP/SRL In Situ Tests: MIIT Program—The Effects of Metal Package Components	723
J.F. Covington, G.G. Wicks, and M.A. Molecke	

Section X. Microwave Applications in Waste Management

The Use of "Self Heating" Ceramics as Crucibles for Microwave Melting Metals and Nuclear Waste Glass	735
E.F. Sturcken	
Characterization of Radioactive Waste Melter Feed Vitrified by Microwave Energy	743
C.M. Jantzen and J.R. Cadieux	
Oxidative Degradation of Trichloroethylene Adsorbed on Active Carbons: Use of Microwave Energy	753
R. Varma and S.P. Nandi	
Application of Microwave Heating Techniques to the Detoxification of Contaminated Soils	761
C.E. George, I. Jun, and J. Fan	
Microwave Reactivation of CIP Spent Carbon	769
I.S. Balbaa, S.J. Oda, K.E. Haque, P.D. Kondos, and R.J.C. MacDonald	
Microwave Processing of Simulated Nuclear Waste Glass	779
R.L. Schulz, Z. Fathi, D.E. Clark, and G.G. Wicks	
Microwave Enhanced Pyrochemical Reactions of PuO₂, UO₂, and U₃O₈	787
E.F. Sturcken and L.E. McCurry	
Index	795

Section I. HLW Program Overviews/ Waste Form Characterization

Waste

Form

Characterization

Overview

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

SAVANNAH RIVER SITE HIGH LEVEL WASTE PROGRAM AND THE DEFENSE WASTE PROCESSING FACILITY

**William D. Pearson
U. S. Department of Energy
Savannah River Field Office
P. O. Box Box A
Aiken, SC 29802**

INTRODUCTION

At the Savannah River Site (SRS) in Aiken, South Carolina, the residue of over thirty years of reprocessing of irradiated nuclear fuels for national defense purposes is currently stored in 51 carbon steel tanks. This is a volume of about 34 million gallons of high level radioactive waste. The Defense Waste Processing Facility (DWPF) is to immobilize the radioactivity in this waste. An overview of the SRS High Level Waste (HLW) Processing is shown in Figure 1.

OVERVIEW

Chemical separations of nuclear materials in the H and F canyons produce HLW as a process waste. Waste handling operations in the F-and H-Area Waste Tank Farms separate the process waste into three parts: highly radioactive insoluble sludge, highly radioactive precipitate, and less radioactive water soluble salts.

HLW TANK FARMS IN THE H AND F AREAS

The concentrated liquid radioactive waste byproduct of the SRS separations process is a strongly caustic solution of nitrate salts. An insoluble and highly radioactive metal oxide sludge is also present in some of the streams which are designated as High Level Waste. These waste streams are pumped from the separations facilities (canyon buildings) to the liquid radioactive waste handling facilities (called the waste tank farms) Located in F-Area and H-Area. The tank farm facilities consist of 51 underground waste tanks with a nominal capacity of one million gallons each. Each Tank Farm also maintains two evaporators for waste concentration, and extensive waste transfer systems.

**Figure 1 Immobilization of Savannah River Plant Waste
TANK FARM**

