CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: NWTRB/SKI/KASAM Workshop on Encapsulation Technologies held in Kyoto, Japan (October 21 and 22, 1994); Materials Research Society Symposium on Scientific Basis for Nuclear Waste Management held in Kyoto, Japan (October 23 to 26, 1994); Visit to the Underground Research Facility at the Tono Mine on October 27; Visits to Power Reactor and Nuclear Fuel Development Corporation (PNC) High-Level Waste Research Facilities on October 27 and October 28 (Tokai Works, Japan); Visit to the Japan Atomic Energy Research Institute (JAERI) on October 28; Visit to Ishikawajima-Harima Heavy Industries (IHI) on October 28 (Tokyo and Yokohama works); Visit to University of Tokyo on October 31, 1994. Visit to the Steering Committee on High-Level Radioactive Waste Project (SHP) in Tokyo on October 31; and Participation in the Pre-Joint Technical Committee (JTC) Meeting for the Analogue Studies in the Alligator River Region (ASARR) Project on October 31 and November 1 in Tokyo. (20-5702-523, 20-5704-132, 20-5704-004, 20-5704-064)

DATE/PLACE: October 21 to November 1, 1994
Kyoto, Tono Mine, Tokai, Tokyo, and Yokohama, Japan

AUTHOR(S): Narasi Sridhar, William M. Murphy, and Peter C. Lichtner

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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

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AUTHOR(S): Narasi Sridhar, William M. Murphy, and Peter C. Lichtner

PERSONS PRESENT: Attendance list attached for the NWTRB Workshop and MRS Conference. The following were the principal personnel visited in the various organizations:

PNC	JAERI	IHI
Akira Honda	Susumu Muraoka	Masatsune Akashi
Mikazu Yui	Muneaki Senoo	Hidekazu Asano
	Keiichi Sekine	Takenori Fukuda

University of Tokyo	SHP	ASARR
Shigeo Tsujikawa	Masayoshi Kyashi	Peter Airey
Tadashi Shinohara	Kiroshi Kisaki	Helen Garnett
Yoichi Kojima		Claudio Pescatore
		Shigeru Moriuchi

BACKGROUND AND PURPOSE OF TRIP:

N. Sridhar was invited to attend a workshop on encapsulation technologies sponsored by the U.S. Nuclear Waste Technical Review Board (NWTRB), the Swedish National Council for Nuclear Waste (KASAM), and the Swedish Nuclear Power Inspectorate (SKI) in Kyoto. N. Sridhar, W. Murphy, and P. Lichtner then attended the Materials Research Society (MRS) Symposium on the Scientific Basis for Nuclear Waste Management held in Kyoto. N. Sridhar presented a paper on container corrosion; W. Murphy served on the technical program committee, chaired two sessions, and presented a paper; and P. Lichtner presented an invited keynote speech and a paper. N. Sridhar was also invited by Ishikawajima-Harima Heavy Industries (IHI) who are involved in the research on corrosion of high-level waste containers in the Japanese program to make a presentation on the CNWRA activities in this area. While in Japan, N. Sridhar also visited the University of Tokyo (Professor Tsujikawa) to exchange ideas on localized corrosion and stress corrosion cracking research. W. Murphy and P. Lichtner participated in a technical tour of the Tono Mine Underground Research Facility which was conducted in association with the MRS symposium. On October 28, W. Murphy gave an invited presentation at PNC and participated in a tour of their laboratories. W. Murphy and P. Lichtner also participated in a seminar at JAERI where they both spoke. On October 31, W. Murphy met with executives of the SHP in Tokyo. Then on October 31 and November 1, W. Murphy attended the pre-JTC meeting for the ASARR project, which was also held in Tokyo.

SUMMARY OF PERTINENT POINTS:

NWTRB/KASAM/SKI WORKSHOP

The agenda of the workshop is attached. The workshop was informal in nature and no official position on issues was implied in the discussions. N. Sridhar has copies of viewgraphs of the presentations. One major concern emerging from this workshop is the lack of direction in the U.S. DOE waste package program, despite the issuance of the Proposed Program Approach (PPA) and the Multipurpose Canister Concept (MPC). Specifically, identification of a small number of materials options is essential to progress in performance assessment of EBS and in the answering of critical fabrication related questions. The lack of specificity regarding materials for the MPC and overpacks was especially evident in the Lawrence Livermore National Labs (LLNL) presentations. For example, Henshall (LLNL) mentioned that they plan to test over 10,000 corrosion coupons of various alloys. Because, detailed monitoring of electrochemical parameters (e.g., corrosion potential) is not planned on such a large sample, these tests are unlikely to yield information useful for long-term prediction. David Stahl (B&W) discussed the U.S. encapsulation technology program. He said that they are considering two thermal loading options: 91-114 kW/acre loading (alloy 825/C-steel double-layer overpack) and 28–40 kW/acre loading (alloy 825/C-steel/Monel 400 or Ti-12 triple layer overpack). The rationale for the inclusion of Monel 400 and Ti-12, two very different alloys in their corrosion characteristics, as outer overpack was not given. The grade of carbon steel can vary from C-Mn steel to 2.25Cr-1Mo alloy steel. The other interesting points in Stahl's presentation include: (i) Nonmetallic materials are fading from consideration, (ii) they are planning to perform a small test program to pour filler (possibly iron shots) inside a container for uncanistered spent fuel after placing the fuel, (iii) they have specified a dry-out procedure for MPC after loading spent fuel from the pool to get the water below 25 g per container, and (iv) they have performed elastic-plastic analysis of a 2 m drop on a sharp point to calculate local stresses. He felt that seismic loading is not important because of the backfill.

Greg Henshall presented their planned research activities on waste package materials. In addition to their long-term tests on 10,000 coupons, they are testing coupons of various alloys in the New Zealand geothermal environment, which is regarded as simulating one of the "bounding" environments likely to be encountered in the proposed Yucca Mountain (YM) repository. Severe corrosion was reported on alloy 825 in this environment. However, the relevance of these tests to performance in repository environments is not at all clear. In the discussion following the presentation of Greg Henshall, it was mentioned that DOE plans to keep the drifts open for 100 yr after emplacement. The exploratory shaft facility (ESF) will have large-scale heater tests and they plan to place selected materials and sensors to measure temperature, moisture, pH, and corrosion potential. It was also mentioned by Stahl that their TSPA calculations indicate that spent fuel dissolution rate is most important and that crushed-tuff backfill is unlikely as an option due to high temperatures calculated. In the presentation by N. Sridhar, the importance of focusing on fewer materials options and monitoring electrochemical parameters during long-term testing were emphasized. Overall, N. Sridhar feels that it is important to soon hold technical exchange meetings with DOE and its contract organizations involved in waste package research on topics related to long-term testing strategy and performance issues.

The Swedish and Finnish programs are focused on thick-walled copper containers, perhaps reinforced by a steel inner container. The main area of contention in the Swedish program between SKB and SKI seems to be the fabrication and inspectability of copper containers. It is the opinion of SKI and its consultant (William Bowyer) that ultrasonic inspection of thick copper welds may be impossible because of large grain sizes (penetration of ultrasonic waves is inversely proportional to the grain size). Lars Werme (SKB) said that they are planning to produce four prototype containers to study these issues. Finland (H. Aalto) is contracting with Mannesmann to make the steel inner containers which will be electron-beam welded. They prefer low alloying, especially in terms of phosphorus content. The German program is focusing on steel containers. They have developed a narrow-gap welding process from Siemens using the gas metal arc process. They have performed extensive drop tests of the welded prototypes. The Swiss program has focused on performance assessment calculations. Their reference design is a thick carbon steel container placed in a deep bentonite backfill which forms the most critical element of their EBS. For them, the performance of carbon steel is not very important. The Japanese reference design is similar to that of the Swiss, with Ti-12 as an alternate material. The Belgian program has tested a wide variety of alloys, including some Ni-base alloys, in their underground clay site at Mol. Unfortunately, they have not measured corrosion potentials of these specimens. The French are just beginning to look at disposal options and they have 15 yr from 1991 to come up with a concept. For the direct disposal of spent fuel, which has not been important for their program, they are considering copper or steel containers, but have not progressed beyond conceptual ideas. The Canadian contingent (represented by Lawrence Johnson, AECL) did not present any information, but their options in terms of either Ti or copper are well known.

MATERIALS RESEARCH SOCIETY SYMPOSIUM

The 18th Annual MRS Symposium on the Scientific Basis for Nuclear Waste Management was held in Kyoto, Japan. Many papers were presented on glass materials, cementitious materials, behavior of uranium in nature, ceramics, performance assessments, etc. Abstracts of papers were published and distributed at the meeting. The full proceedings should appear in the near future as an MRS publication. W. Murphy announced at the meeting that he will chair the 1995 nuclear waste management MRS symposium in Boston. He received many useful suggestions and applications for participation from participants. Several individuals presentations of particular note are described in the following paragraphs.

From the point of view of container performance, important talks pertained to possible microbial effects. Simcha Stroes-Gascoyne presented a paper on microbial studies in the underground research laboratories at Whiteshell. In their 2.5 yr test using a heater (65–85 °C), few methanogens or sulfate reducing bacteria (SRB) were found to survive. However, aerobic bacterial activity was detected and corrosion of thermocouple material was found to be due to microbiologically influenced corrosion. Fukunaga et al. (IHI) presented a paper investigating the effect of environmental conditions (pH, Eh) on survival of SRB. No SRB was detected at pH above 10 or at high Eh values.

A number of papers addressed issues directly relevant to the geology, hydrology, and geochemistry of the YM site. S. Sato presented a paper on the thermodynamic properties of water in bentonite at various water contents, which relates to the basic properties of unsaturated media. The activity of water remains equivalent to bulk water until the water content drops below 15 weight percent. Remaining water was interpreted to be mainly intracrystalline.

D. Chesnut (in absentia) presented a poster on methods for quantitative evaluations of groundwater flux and travel time and radionuclide release at YM. Observing that permeability variability is approximately log normal, travel time distributions were obtained for various log normalities and coupled to EBS release functions to obtain radionuclide releases.

T. Buscheck presented numerical simulations of thermohydrological responses of YM to a repository. He emphasized the role of relative humidity at the repository horizon on the rate of container corrosion. The best cases with regard to container corrosion would be low humidity at higher temperatures such as those occurring for high thermal loading regimes.

W. Murphy showed modeling results and site data bearing on groundwater flow at YM. C-14 in the unsaturated zone at YM can be reasonably explained by diffusion from the ground surface, coupled with equilibrium gas-liquid interactions and radioactive decay. These results indicate that the C-14 distribution in the unsaturated zone can be explained with minimal liquid flow, and that C-14 activities are unrelated to unsaturated zone groundwater ages. Saturated zone groundwaters at YM are undersaturated chemically with respect to calcite. The occurrence of calcite in the rocks there indicates that saturated zone flow is channelized, bypassing zones of the rock that contain calcite. This result is supported by stable isotopic data and a correlation between relatively permeable zones and the absence of calcite.

P. Lichtner presented modeling results of natural analogue sites at Poços de Caldas, Brazil and Peña Blanca, Mexico for the alteration of uraninite. He was able to explain the bleached zone observed in the redox fronts at Poços de Caldas, and could describe the paragenesis for the alteration of uraninite at Peña Blanca under oxidizing conditions.

A paper entitled "The use of repassivation potential in predicting the performance of high-level nuclear waste container materials" was presented by Narasi Sridhar. The paper was well received. Rolf Sandstrom (KASAM) asked whether the repassivation potential measured by cyclic polarization tests can be used only for ranking alloys or can also be used for predicting long-term occurrence of localized corrosion. The author addressed this question in terms of the effect of scan rate and pit depth on the measured repassivation potential and if measured on deep pits at a slow enough scan rate can be used to predict long-term occurrence of pits or crevice corrosion. M. Akashi (IHI) asked whether CNWRA plans to perform stress corrosion cracking tests on sensitized alloy 825 in light of the lowering of repassivation potential due to sensitization. We are currently conducting such tests.

J. Westall in an invited talk entitled: "Modeling of Metal Speciation in the Environment: Association of Metals with Heterogeneous Environmental Sorbents," proposed a new approach for describing adsorption, referred to as the "discrete log K spectrum" approach. Westall argued that the complexity of surfaces found in natural systems makes "mechanistic" surface complexation and diffuse layer models impractical for use in repository performance assessments.

Jordi Bruno gave a presentation on UO_2 dissolution under oxidizing conditions. One of the interesting points he made concerned the solubility of uranophane. The equilibrium solubility constant for uranophane they found experimentally was log K = −7.8 while the value from the EQ3 database is −9.2. They also found that the dissolution rate of uranophane corresponded to 1 mm in 188,000 years.

Lawrence Johnson gave a presentation on behalf of David Shoesmith (AECL) regarding the effect of alpha radiation on the dissolution behavior of unirradiated UO_2. The corrosion potential of the UO_2 specimen increased dramatically (over 400 mV) with increasing alpha activity, mainly due to radiolysis effects. Gamma radiolysis effects on UO_2 in a repository setting would be negligible assuming the container lasts for greater than 500 years.

TONO MINE UNDERGROUND RESEARCH FACILITY

The Tono Mine is an underground research facility operated by PNC with uranium exploration and nuclear waste research objectives. It is located near Toki City (near Nagoya) at an unconformity between Cretaceous granites and Miocene clastic sedimentary rocks. W. Murphy and P. Lichtner toured the facility on October 27 with members of a technical tour from the MRS symposium. Studies there related to waste disposal have focused on hydrogeology, hydrogeochemistry, isotope chemistry, radionuclide migration, chemistry of EBS materials, rock mechanics, and development of instrumentation. Most studies have been on sedimentary rocks which host the subeconomic uranium deposit. W. Murphy has some literature on these activities.

POWER REACTOR NUCLEAR FUEL DEVELOPMENT CORPORATION VISIT (TOKAI WORKS)

The Tokai Works plant employs about 1,200 full-time staff and is the focus of research and development on much of the uranium fuel cycle including enrichment, fabrication, reprocessing, and disposal. Their main program in the high-level waste disposal area, called ENTRY project, consists of both small-scale laboratory studies and large-scale *in situ* experiments. In the waste package area, their experimental investigations focused on localized corrosion growth of carbon steel under a saturated, compacted bentonite buffer. They are using a simulated pit solution to measure pit growth rates. They also use extreme value statistical approach to scale the maximum pit depth from laboratory size specimens to actual container size. However, the type of pitting they observe are broad, shallow pits. They have contracted with Susan Sharland (AEA Technologies, U.K.) to perform modeling of pit growth using the CAMILLE code. N. Sridhar gave an invited presentation to the waste package research group on current activities at CNWRA.

There are approximately 20 geochemists at the PNC Tokai Works who work with many contractors in an ambitious and broad program of experimentation and performance assessments. W. Murphy met with a group of PNC geologists and geochemists on October 28 who described their work generally. Then W. Murphy gave a talk on the geochemistry of YM. W. Murphy then toured new laboratory facilities which are expansive. Of particular significance is an instrumented test being set up on a 1 m^3 block of

silicic tuff. Comparisons of results from this test under saturated conditions to those obtained in similar tests under unsaturated conditions for the YM Project could be illuminating.

JAPAN ATOMIC ENERGY RESEARCH INSTITUTE

W. Murphy and P. Lichtner visited JAERI on October 28 and attended two seminars, one in which W. Murphy and P. Lichtner spoke together with Dr. Higgo from BGS, and the other on natural analogs at which W. Murphy spoke together with Japanese scientists working on the ASARR project. Uranium series data from Alligator Rivers indicating strong ^{234}U depletions in groundwater are especially interesting and difficult to understand.

ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES VISIT (TOKYO AND YOKOHAMA WORKS)

IHI is a large company (16,000 employees and consolidated net sales of $10 billion) involved in many areas of construction and manufacturing. N. Sridhar visited the research group involved in the high-level waste package fabrication and performance assessment. Their experimental techniques are similar to those used by PNC (PNC adopted the techniques developed by IHI which in turn evolved from the University of Tokyo). They are extremely interested in CNWRA activities because of the similarities of some of the techniques. They have visited LLNL once, but have not continued their contact because of lack of activity at LLNL in this area. N. Sridhar made a presentation of CNWRA studies and the roles of NRC, DOE, and EPA in the waste disposal program.

UNIVERSITY OF TOKYO

On October 31 N. Sridhar visited the University of Tokyo. Of most relevance to the repository program are the studies of crevice corrosion growth, stress corrosion cracking, and marine exposure tests. Shinohara et al., are using a novel method to measure crevice corrosion growth by shifts in Moiré fringe patterns between glass and the metal specimen. This is then compared to the stress corrosion crack growth rate to determine which will be a dominant failure mode for a given environment-material combination. In the marine exposure tests, the corrosion potential of metal coupons exposed to seawater at Shimizu site near the inland Sea of Japan are monitored (the seawater for testing is brought in by ship from deeper waters in the Pacific). The corrosion potential of stainless steel is about 300 mV versus saturated calomel electrode, which is much higher than would be expected in aerated environments. This is in agreement with many other studies and is generally attributed to microorganisms catalyzing the oxygen reduction reactions. Ms. Ishizawa, a microbiologist, is evaluating the role of various aerobic bacteria by culturing these organisms and inoculating artificially prepared sterile seawater. They have also developed a sensor for atmospheric corrosion that can be used to measure the salt concentration due to evaporation of seawater. A similar technique may be used to monitor the effects of repository vadose zone water evaporation effects. Overall, the approach used by this group in terms of measuring corrosion and repassivation potentials and growth rates of crevices and cracks is very similar to that followed by CNWRA.

STEERING COMMITTEE ON HIGH-LEVEL-RADIOACTIVE-WASTE PROJECT

On October 31, W. Murphy was escorted to the offices of the SHP in Tokyo by a member of JAERI who served as a translator. W. Murphy met with the secretary general and the chairman of the relatively new and small organization. Their role is to promote preparation for the projects that will ultimately have

responsibility for nuclear waste disposal. This organization has a high level and far sighted responsibility to promote the smooth operation of waste disposal in the next century. W. Murphy described the roles of the institutions in the US with responsibility for waste management, including the context in which the CNWRA works.

PRE-JOINT TECHNICAL COMMITTEE MEETING FOR THE ANALOGUE STUDIES IN THE ALLIGATOR RIVERS REGION PROJECT

W. Murphy attended the pre-JTC for ASARR in Tokyo on October 31 and November 1. The objective of the meeting was to take preliminary actions to formalize an international agreement among JAERI, ANSTO of Australia, NRC, and KAERI of Korea to develop the project. W. Murphy's primary activity was to offer impromptu technical comments on technical presentations by researchers engaged in studies at Alligator Rivers. He also took notes on the proceedings of the meeting which were provided informally to W. Ott and L. Kovach.

SUMMARY OF ACTIVITIES:

N. Sridhar presented a talk at the NWTRB workshop entitled "Long-Term Prediction of the Performance of the Engineered Barrier System." A paper co-authored by N. Sridhar with D. Dunn and G. Cragnolino entitled "The use of repassivation potential in predicting the performance of high level nuclear waste container materials" was presented at the MRS conference. At IHI, N. Sridhar gave a talk entitled "Engineered Barrier System Program at CNWRA." N. Sridhar also made a brief presentation at PNC on CNWRA and on various activities in the EBS group.

W. Murphy served on the Technical Program Committee for the MRS symposium and chaired oral and poster sessions on Reactive Transport and Microbes. He presented a talk titled "Contributions of Thermodynamic and Mass Transport Modeling to Evaluations of Groundwater Flow and Groundwater Travel Time at Yucca Mountain, Nevada," and a peer reviewed paper by this title was submitted to the symposium proceedings. At PNC and at JAERI, W. Murphy gave the oral presentation "Gas-Water-Rock Geochemistry of Yucca Mountain, Nevada," and at JAERI he gave a short lecture on "Natural Analog Research at the CNWRA."

P. Lichtner attended the MRS Symposium and presented an invited talk entitled: "Principles and Practice of Reactive Transport Modeling." A peer reviewed paper by this title was also submitted to the symposium proceedings. P. Lichtner visited JAERI where he participated in a meeting on the use of EQ3/6 in modeling and gave a lecture on "Reactive Transport in Porous Media."

IMPRESSION/CONCLUSIONS:

The NWTRB workshop was very useful in obtaining a broad perspective on the approaches to waste package design and fabrication used by various countries. The lack of focus of the U.S. waste package design materials was apparent and remarked upon by many participants. The Japanese waste package concept may be significantly different from the U.S. concept, but the methodology for performance prediction is similar to that proposed by CNWRA. The long-term seawater exposure tests by the University of Tokyo group may shed important light on the action of aerobic bacteria on waste package materials.

The quality of papers at the MRS symposium was good. The number and diversity of papers was large, and the proceedings should be valuable. Presentations were dominated by the Japanese and were generally highly literate in English. Progress in attacking difficult technical problems in nuclear waste management is evident, notably in fields of hydrochemical coupling and bio/organic effects.

New laboratories at PNC are particularly impressive and should permit generation of much significant data.

Studies at Tono and at Alligator Rivers are interesting and technically competent, but applications to nuclear waste disposal issues appear to be addressed only vaguely.

PROBLEMS ENCOUNTERED:

None

PENDING ACTIONS:

None

RECOMMENDATIONS:

In terms of waste package performance prediction approaches, there is a need for a technical exchange between NRC/CNWRA and DOE/LLNL/B&W. Such a technical exchange may also help guide DOE in its long-term corrosion testing strategies. The use by PNC and IHI of extreme value statistics to scale the specimen size to container size needs to be explored by CNWRA. Continued contact between the CNWRA and the various Japanese organizations involved in waste package research will be highly beneficial.

Laboratory studies on the 1 m^3 tuff block experiments at PNC should be followed and comparisons made to results of unsaturated tuff block studies by the DOE. Relations between the two could elucidate the significance of unsaturated conditions at YM. A technical meeting to compare results should be held in the future at an intermediate location, e.g., Hawaii.

REFERENCES:

None

SIGNATURES:

Narasi Sridhar
Principal Engineer

11/17/94
Date

William M. Murphy
Principal Scientist

11/18/94
Date

Peter C. Lichtner
Principal Scientist

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Date

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11/18/94
Date

H. Lawrence McKague
Element Manager - GS

11/22/94
Date

Budhi Sagar
Technical Director

12/7/94
Date

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attachments
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INTERNATIONAL WORKSHOP ON ENCAPSULATION TECHNOLOGY AGENDA

Agenda

International Workshop on Encapsulation Technology

Friday October 21, 1994
Saturday October 22,1994

Miyako Hotel
Sanjo Keage, Kyoto 605
Telephone: 075-771-7111
Telefax: 075-751-2490

Friday, October 21 (Atago-no-ma room)

8:55 A.M. **Welcome and opening remarks**
Ellis Verink, United States Nuclear Waste Technical Review Board (NWTRB)
Rolf Sandström, Swedish National Council for Nuclear Waste (KASAM)
Rolf Sjöblom, Swedish Nuclear Power Inspectorate (SKI)
All participants, self-introduction

NATIONAL ENCAPSULATION TECHNOLOGY PROGRAMS

Introduction
Carl Di Bella and Rolf Sjöblom, Session Moderators

9:15 A.M. **Encapsulation Technology in the Swedish Radioactive Waste Disposal Program**
Lars Werme, Swedish Nuclear Fuel and Waste Management Company (SKB)

9:45 A.M. **Encapsulation Technology in the U.S. Radioactive Waste Disposal Program**
David Stahl, B&W Fuel Company

10:15 A.M. **Encapsulation Technology in the Finnish Radioactive Waste Disposal Program**
Jukka-Pekka Salo, Industrial Power Company (TVO) and
Harri Aalto, Outokumpu Copper (Postgrad study at U. of. Tokyo)

10:45 A.M. **BREAK (15 minutes)**

11:00 A.M. **Encapsulation Technology in the Swiss Radioactive Waste Disposal Program**
Ian McKinley, National Cooperative for the Disposal of Radioactive Waste (NAGRA)

11:30 A.M.	**Encapsulation Technology in the German Radioactive Waste Disposal Program** Harry Spilker, Company for Nuclear Service, (GNS)
12:00 noon	**Encapsulation Technology in the Japanese Radioactive Waste Disposal Program** Hirohisa Ishikawa, Power Reactor & Nuclear Fuel Development Corporation (PNC)
12:30 P.M.	**LUNCH (together in the Hieri-no-ma room) (1 hour, 15 minutes)**

NATIONAL ENCAPSULATION TECHNOLOGY PROGRAMS (continued)

1:45 P.M.	**Encapsulation Technology in the French Radioactive Waste Disposal Program** Sylvie Voinis, National Waste Management Agency (ANDRA)
2:15 P.M.	**General Trends for Geologic Disposal in Belgium** Robert Gens, National Organization for Radioactive Waste and Fissile Material (NIRAS/ONDRAF)
2:45 P.M.	**BREAK (15 minutes)**
3:00 P.M.	**Round-table discussion** All attendees (Rolf Sandström, moderator)

Saturday

- What are the common encapsulation technology interests between the "direct-disposal" and the "reprocessing" countries?
- What are the common waste package interests among the "unsaturated-zone-repository" and the "saturated-zone-repository" countries?
- What role should the container play in a waste disposal system (as opposed to the engineered barrier outside the container or the geologic barrier)?
- Is there adequate balance in your program with regard to encapsulation technology work? What areas need more (or less) attention?
- What areas of encapsulation technology development may be of generic interest?
- What is the appropriate strategy for technology development. How much should risk be balanced with redundancy? How should one plan for/handle the inevitable problems along the technology development path?

5:00 P.M.	**Recess**
6:30 P.M.	**Cash bar (???? room)**
7:30 P.M.	**Dinner (Minori-no-ma room)**
9:30 P.M.	**Recess until Saturday morning**

Saturday, October 22 (Atago-no-ma room)

8:30 A.M.	**Reconvene meeting** Carl Di Bella, NWTRB
	MATERIALS SELECTION
	Introduction Ellis Verink, NWTRB, Session Moderator
8:35 A.M.	**Plans, Status, and Objectives of U.S. Waste Package Materials Research Program** Greg Henshall, LLNL
9:00 A.M.	**Long-Term Prediction of the Performance of the Engineered Barrier System** Narasi Shridar, Center for Nuclear Waste Regulatory Analyses (CNWRA)
9:30 A.M.	**Relationship of Corrosion, Ductility, and Creep to Manufacturing and Performance** Rolf Sandström, KASAM
10:00 A.M.	**BREAK (15 minutes)**
	FABRICATION AND PERFORMANCE PREDICTION
10:15 A.M.	**Introduction** Hans-Peter Hermansson, Studsvik Material AB Session Moderator
10:15 A.M.	**Corrosion models in recent U.S. performance assessments** Carl Di Bella, NWTRB
10:45 A.M.	**Often Neglected Barriers within the Waste Package** Willis Clarke, Lawrence Livermore National Laboratory (LLNL)
11:15 A.M.	**Fabrication, Quality Assurance, and Related Items** Hidekazu Asano, Ishikawajima-Harima Heavy Industries
11:45 A.M.	**What to Look for When Developing Encapsulation Technology** W. Bowyer, ERA Technology (consultant to SKI)
12:15 P.M.	**Lunch (Circular Room) (1 hour 15 minutes)**
1:30 P.M.	**Closing Round-table Discussion** All attendees (Carl Di Bella, moderator) • In view of the important role for waste packages, is enough research emphasis being placed in the area of encapsulation? • Are we truly confident in our very-long range safety performance predictions? If not, what do we still need to do in the way of research or demonstration?

- What waste package materials issues need the most immediate attention?
- Which are the more important technology development concerns (e.g., welding, corrosion, materials selection, etc)?
- Which encapsulation technology issues are most important for long term safety?
- What are the role and requirements for encapsulation technology for long term safety? What is "long term?"
- In your safety analysis/performance assessment program do encapsulation technology issues have a proper place? If not, how should one go about seeing that they gain their proper place?

2:45 P.M.	**BREAK (15 minutes)**
3:00 P.M.	**Continue Closing Round-table Discussion**
4:30 P.M.	**Summary, closing remarks, and adjournment** Rolf Sjöblom, SKI

INTERNATIONAL WORKSHOP ON ENCAPSULATION TECHNOLOGY REGISTERED ATTENDEES

International Workshop on Encapsulation Technology
Registered Attendees
October 21-22, 1994

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XVIII INTERNATIONAL SYMPOSIUM ON THE SCIENTIFIC BASIS FOR NUCLEAR WASTE MANAGEMENT PARTICIPANTS LIST

Participants List

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on the

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for

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October 23 - 27, 1994

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J-031	Tagami	Keiko	National Institute of Radiological Sciences	Japan
J-112	Takada	Masaiti	Kansai Electric Power Co., Inc.	Japan
J-011	Takagi	Shinji	Kanagawa University, Faculty of Science	Japan
J-073	Takahashi	Yoshio	University of Tokyo	Japan
J-161	Takahashi	Kazuyoshi	Tokyo Electric Power Company	Japan
J-124	Takaji	Kazuhiko	Takenaka Corporation	Japan
J-153	Takase	Hiroyasu	JGC Corporation	Japan
J-204	Takase	Toshio	Mitsubishi Materials Corporation	Japan
J-210	Takeda	Seietsu	Power Reactor & Nuclear Fuel Development Corp.	Japan
J-162	Takemura	Tomoyuki	Mitsui Mining & Smelting Co., Ltd.	Japan
J-081	Takeuchi	Mitsuo	Japan Nuclear Fuel Limited	Japan
J-083	Tamura	Yukito	Japan Atomic Energy Research Institute	Japan
J-076	Tanaka	Tadao	Japan Atomic Energy Research Institute	Japan
J-192	Tanaka	Hiroshi	Central Research Institute of Electric Power Industry	Japan
J-219	Tanaka	Satoru	University of Tokyo	Japan
J-063	Tashiro	Shingo	Radioactive Waste Management Center	Japan
J-041	Tochiyama	Osamu	Tohoku University, Faculty of Engineering	Japan
J-086	Tomita	Ryuzo	Koa Development Co.,	Japan
J-099	Toyohara	Masumitsu	Toshiba Corp.	Japan
J-089	Tsuboi	Takashi	Japan Atomic Energy Research Institute	Japan
J-168	Tsuji	Yukikazu	Gunma University	Japan
J-208	Tsuji	Tadashi	Nomura Research Institute	Japan
J-057	Tsujikawa	Shigeo	University of Tokyo, Faculty of Engineering	Japan

Log	Last	First	Institution	Country
J-017	Tsukamoto	Masaki	Central Research Institute of Electric Power Industry	Japan
J-182	Tsukamoto	Koji	Okumura Corp.	Japan
J-033	Tsukimura	Katsuhiro	Geological Survey of Japan	Japan
J-030	Uchida	Shigeo	National Institute of Radiological Sciences	Japan
J-117	Ueta	Shinzo	Mitsubishi Materials Corporation	Japan
J-125	Umedera	Makoto	Sumitomo Metal Minig Co., Ltd.	Japan
J-209	Umeki	Hiroyuki	Power Reactor & Nuclear Fuel Development Corp.	Japan
J-048	Uno	Masayoshi	Osaka University, Faculty of Engineering	Japan
J-075	Uranishi	Yoshie	Nuclear Engineering, Ltd.	Japan
J-013	Wada	Yukio	Power Reactor and Nuclear Fuel Development Corporation	Japan
J-216	Wada	Ryutaro	Kobe Steel, Ltd.	Japan
J-009	Wadachi	Yoshiki	The Institute of Applied Energy	Japan
J-191	Watanabe	Tsuneo	Mitsubishi Nuclear Fuel Co., Ltd.	Japan
J-121	Yabe	Ichiro	Nuclear Safety Research Association	Japan
J-029	Yagi	Eiji	Mitsubishi Materials Corp.	Japan
J-190	Yamakawa	Minoru	Power Reactor & Nuclear Fuel Development Corp.	Japan
J-010	Yamamoto	Yutaka	The Institute of Applied Energy	Japan
J-064	Yamamoto	Masafumi	Radioactive Waste Management Center	Japan
J-078	Yamamoto	Tadashi	Osaka University	Japan
J-137	Yamamoto	Mikihiko	Toyo Engineering Corporation	Japan
J-212	Yamamoto	Masao	Power Reactor & Nuclear Fuel Development Corp.	Japan
J-221	Yamamoto	Osamu	The Japan Atomic Power Company	Japan
J-148	Yamanaka	Hiroshi	Osaka National Research Institute, AIST	Japan
J-150	Yamanouchi	Jiro	Nishimatsu Construction Ltd.	Japan
J-183	Yamashita	Ryo	Hazama Corporation	Japan
J-025	Yamazaki	Hiromichi	Tohoku University, Dept. of Nuclear Engineering	Japan
J-060	Yanase	Nobuyuki	Japan Atomic Energy Research Institute	Japan
J-039	Yasuda	Hiroshi	National Institute of Radiological Sciences	Japan
J-180	Yokoe	Kenichi	Taisei Corporation	Japan
J-114	Yokote	Mitsuhiro	Kansai Electric Power Co., Inc.	Japan
J-003	Yokoyama	Hayaichi	CRIEPI	Japan
J-202	Yoshikawa	Hideki	Power Reactor & Nuclear Fuel Development Corp.	Japan
J-178	Yusa	Yasuhisa	Power Reactor & Nuclear Fuel Development Corp.	Japan
J-059	Zhang	Ming	Kyushu University, Faculty of Eng.	Japan