CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: The 10th International High-Level Radioactive Waste Management Conference (IHLRWM)
Project No. 20.06002.01.081; AI 06002.081.307

DATE/PLACE: March 30–April 3, 2003
Las Vegas, Nevada

AUTHORS: B. Sagar, A. Chowdhury, G. Cragnolino, B. Dasgupta, V. Jain, C. Manepally, S. Mohanty, W. Patrick, J. Stamatakos, D. Waiting, J. Winterle

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PERSONS PRESENT:

B. Sagar, A. Chowdhury, G. Cragnolino, B. Dasgupta, V. Jain, C. Manepally, S. Mohanty, W. Patrick, J. Stamatakos, D. Waiting, and J. Winterle from the Center for Nuclear Waste Regulatory Analyses (CNWRA), several staff members from U.S. Nuclear Regulatory Commission (NRC) and about 450 representatives from various countries.

BACKGROUND AND PURPOSE OF TRIP:

This is the premier conference in the radioactive waste management arena. It has become an increasingly international forum, with particularly extensive participation from Europe and Asia this year.

Staff members of the CNWRA were involved at all levels of the meeting. Roles included deputy technical program chair, two lead organizers, several session organizers and session chairs, and a number of presenters. CNWRA staff also participated as judges for the poster session.

Copies of the CD-ROM of the conference presentations are available for those interested in more details.

SUMMARY OF PERTINENT POINTS:

Site Characterization

There were five presentations in the session on Site Characterization. The first two papers in the session were summaries of recent field and laboratory thermal conductivity measurements of the lower lithophysal unit of the Topopah Spring tuff. The presentations were made by N. Brodsky of Sandia National Laboratory. The third paper was on *in-situ* and laboratory measurements of diffusion in granitic rocks (Canadian program). This paper was presented by P. Vicks of AECL-Canada.

These three presentations emphasized three important points. First, the scale at which the measurements were conducted influenced the estimates of conductivity and diffusion. *In-situ* thermal conductivities and diffusion measurements were generally greater than those made

from laboratory samples. Second, both *in-situ* and laboratory samples can yield biased results because of sample extraction, sample preparation, or other procedural limitations. For example, granite samples from deep underground mines in Canada are subjected to relatively high stresses in the subsurface. Removal of material by mining and/or sample preparation in the laboratory causes the stresses in the granite to relax and the sample properties to change. Third, reliable and accurate estimates of thermal conductivity and diffusion, especially those that are to be used in performance assessments, depend on a combination of laboratory, *in-situ*, and modeling results.

The other two papers in the session were aimed at understanding saturation zone flow in Amargosa Desert and Fortymile Wash. The first of these was presented by J. Stamatakos, in which he summarized the stratigraphic analyses of the deeper basin strata observed in the Nye County wells. The second paper was an analysis of the C-Well complex hydrologic data by Sandia National Laboratory. The goal of this work was to constrain the amount of horizontal anisotropic transmissivity used in ground water flow models.

Disruptive Events

There were four papers presented in ths session on Disruptive Events. The first paper described the two methodologies used by the CNWRA staff to of evaluate the risk significance of faulting to post-closure performance. The paper was presented by D. Waiting.

The second paper was a detailed description of the volcanic stratigraphy found in the boreholes and trenches in Midway Valley and on the pad site. The boreholes and trenches were part of a detailed examination of the subsurface material necessary for preclosure geotechnical analyses, including site response analysis. This presentation was made by D. Busch of the United States Geological Survey.

The third talk of this session was on the applicability of smelters as analogs for how different types of nuclear material would be incorporated into volcanic dust during a potential volcanic eruption at Yucca Mountain. The talk pointed out that previous analyses of radioactivity at smelters could provide some data to constrain an igneous source term. This presentation was made by Benjamin Ross of Disposal Safety.

The fourth and last talk in the session was on the development of an alternative source term for igneous activity. The alternative source term included incorporation of more dense ash material once heavier nuclear waste material is incorporated into the volcanic ash. This presentation was made by R. Codell of the NRC.

Unsaturated and Saturated Flow Under Isothermal Conditions

Several presentations were pertinent to ongoing reviews of the Unsaturated and Saturated Flow under Isothermal Conditions key technical issue. S. James of Sandia Laboratories presented an overview of a proposed approach for considering anisotropic saturated zone flow in the U.S. Department of Energy (DOE) performance assessment model; this approach was developed to address an existing NRC-DOE agreement item. Several presentations by U.S. Geological Survey researchers J. Whelan, B. Marshall, and L. Neymark provided useful information regarding the topic of potential upwelling of geothermal fluids beneath Yucca Mountain. These presentation topics included the reliability of using uranium, thorium, and

lead isotopes to date secondary minerals, and modeling of the thermochronology of secondary minerals at Yucca Mountain. J. Paces, also from the U.S. Geological Survey, presented a summary of chlorine-36 validation studies at Yucca Mountain.

Surface and Subsurface Facilities–Design and Testing

The session on Surface and Subsurface Facilities–design and Testing comprised five papers from the us and abroad. Companion papers by P. McDaniel on surface facilities and A. Linden (both of Bechtel SAIC) on subsurface facilities provided an overview of the design approach and principal design features of the proposed repository at Yucca Mountain. They emphasized flexibility in design, but acknowledged in the question and answer period the need to balance flexibility against producing a clear and complete evaluation of safety and regulatory compliance. The proportion of rail versus truck shipments, need for wet transfer facilities, and options for surface and subsurface aging facilities are among the design features that remain to be resolved.

The use of the Aspo Hard Rock Laboratory for demonstration and verification of repository technologies was the focus of a presentation by C. Svemar (SKB, Sweden). Although Svemar repeatedly observed the Aspo demonstrations were mainly for the benefit of public confidence, it was clear from audience questions that many of the topics address matters of concern to engineers (e.g., backfill wetting and swelling, rock mechanical response of simulated emplacement drifts, and various handling system demonstrations).

S. Vomvoris (NAGRA, Switzerland) provided an update on Phase V and plans for Phase VI of the Grimsel test site. A number of the tests are cast primarily as engineering demonstrations. Although most of his presentation focused on test layouts, instrumentation, and preparation techniques, audience questions led to clarification that NAGRA and other participants conduct experiment designs and, where appropriate, pre-test calculations that can be used as a point of reference for comparisons with data. Phase VI will focus heavily on investigations of colloids, retardation, long-term diffusion, and related topics. Vomvoris briefly described the International Training Center School of Underground Waste Storage and Disposal (ITC), which will begin operations in early April.

The final paper in the Surface and Subsurface Facilities—Design and Testing session was given by J. Astudillo (ENRESA, Spain). Astudillo summarized the ENRESA program, which focuses on argillaceous materials as potential disposal media. Their research and development program is quite comprehensive. The ENRESA research and development program appears to repeat many of the studies conducted at the Mol, Belgium facility and in the Opalinus clay in Switzerland. This is justified because the materials under investigation are quite different from those at the other sites (i.e., about mid-way between them in terms of strength and deformability).

Thermal Effects in Emplacement Drifts

The Thermal Effects in Emplacement Drifts–I featured a set of three papers by SNL and contract researchers [D. James (Texas Tech), S. Webb (SNL), and M Itamura (SNL)]. Taken together, their work represents the current SNL capability and results of modeling ventilation in and around waste packages and related tests. SNL uses the computational fluid dynamics (CFD) code FLUENT as the primary tool for these investigations. A significant result is that an

estimated 85 percent of the decay heat of emplaced waste would be removed by ventilation. Webb reported on differences between the effective conductivity approach used in performance assessment calculations and more detailed CFD results. Not surprisingly, the results differ substantially near the invert, where the waste-package-drift-wall gap is much narrower than elsewhere. Audience discussion suggested using more than one zone of effective conductivity to better represent heat transfer conditions. Itamura specifically examined the low temperature operating mode for the proposed repository using FLUENT.

R. Akberov (UNLV) presented simulations of heat transfer in proposed repository drifts. In contrast with the SNL work and a broad literature on the subject, his results indicated minor effects from thermal radiation. Based on discussions with the audience, it appears that the root cause of this anomaly is his assumption that the drift air/moisture phase was optically thick, which is not likely to be true.

The final paper in the Thermal Effects in Emplacement Drifts–I session summarized work by Danko and others (University of Nevada–Reno) on powered and passive, natural ventilation. Danko and his colleagues have developed a MULTIFLUX 3.0 code that couples a heat and moisture flow code (a derivative of NUFT) with a rock-mass model and simplified output from a CFD code through a user interface. His principal conclusion is that natural ventilation will continue to remove a significant amount of heat and moisture even if/after the drifts are backfilled. Relative humidity was shown to remain below 50 percent for an extended period (on the order of 5,000 years).

Three papers were presented in the second session of the Thermal Effects in Emplacement Drifts. This session was co-chaired by B. Dasgupta. The first paper was presented by N. Francis from Sandia National Laboratories. Francis and his co-authors presented sensitivity studies to ascertain the potential range in peak waste package temperature for a low temperature operating mode during the post-closure period. The two-dimensional computational fluid dynamic analysis code FLUENT was used to model turbulent flow conditions in the drift considering a range thermal properties (surface emissivity and thermal conductivity) for waste package, drip shield, invert, and drift wall host rock. The study showed that peak temperature is mildly influenced by the range of thermal properties and flow models selected in the analysis.

G. Danko and D. Bahrami from the University of Nevada, Reno studied sensitivity of temperature and relative humidity for emplacement drifts to the variations of site related parameters such as rock heat conductivity, thermal diffusivity and heat transfer coefficient and ventilation parameters. The authors used the MULTIFLUX code coupled with the heat and moisture flow code NUFT in their analyses. The main conclusion of their study was that error in predicted temperature heat removal rates may be as high as 50–100 percent due to input data uncertainties. This finding may be important as the high uncertainty is associated with evaluation of the thermophysical properties of lithophysal rock at Yucca Mountain.

The last paper was presented by S. Dunn from Science Engineering Associates, New Mexico. Dunn and coauthors presented results from the ventilation test conducted at the DOE/North Las Vegas Atlas facility. Twenty-two ventilation tests were conducted in two phases for evaluating the ability of ventilation air to remove heat energy under varying flow conditions, input temperature and moisture contents and waste package power conditions. During the discussion, the authors expressed that these tests were not intended to simulate the drift

thermal conditions. The primary aim of this study was to produce data for validation of ANSYS and FLUENT codes, which would be used in the Yucca Mountain project to model drift ventilation.

Waste Forms

The session on Waste Form comprised of five papers from the US and abroad. Papers by J. Jarden (ANL) and J. Tulenko on dissolution behavior of Urania-Thoria fuels provided results on irradiated Urania-Thoria fuel from Shippingport Light Water Breeder Reactor and simulated non-radioactive Urania-Thoria fuel. Their results indicated that even in oxidizing environments after 200 days, dissolution of U from Urania-Thoria fuels is significantly limited by the presence of Thoria in the matrix and is at least two orders of magnitude lower than those of UO2 spent fuel under similar test condition. This fuel accounts for a very small quantity of spent nuclear fuel that is planned for disposal at the proposed Yucca Mountain repository.

J. Fortner (ANL) reported synchrotron x-ray absorption spectroscopy (XAS) results on spent nuclear fuel alteration phases such as uranyl oxyhydroxide specimens containing Np to establish upper limits for Np incorporation in spent nuclear fuel alteration products. Results showed that a previous study that identified high concentrations of Np in dehydrated schoepite phases using electron energy loss spectroscopy cannot be verified. They attributed this discrepancy in the electron energy loss spectroscopy data to a peculiar plural-scattering event that creates a spurious peak at the Np-M5 energy. These results indicate that incorporation of Np as a solid solution in dehydrated schoepite formed as spent fuel corrodes may not be an important process controlling the dissolved concentration of Np in the potential repository at Yucca Mountain.

The presentation by R. Aguilar (SNL) reported changes made to the Total System Performance Assessment models for colloid formation, stability and potential transport within the engineered barrier system of the proposed Yucca Mountain repository. The colloids models is based on new data acquired from continued testing at ANL and considers the potential effects of commercial spent nuclear fuel and defense spent nuclear fuel generated colloids to the total colloid source term modeled for Total System Performance Assessment for license application. It also incorporates the use of groundwater colloids data from the vicinity of Yucca Mountain to develop the parameters representing the natural groundwater colloids that could potentially contribute to the sorption and transport of radionuclides within the engineered barrier system. Additionally, the presenter discussed the results of ongoing experimental work on steel corrosion of miniature waste packages exposed to water chemistry compositions simulating those anticipated under repository conditions that showed the production and transport of significant quantities of iron oxide colloids.

The second session on waste form had three interesting papers in addition to a paper discussing a graphite waste form for high temperature gas cooled reactor spent nuclear fuel. The paper by Barrie McLeod (JAI Corporation) presented a methodology for the projection of spent nuclear fuel discharges applicable to the spent nuclear fuel assembles that will be delivered to the DOE for repository disposal. It is interesting to note that the total amount of historical and projected discharged spent nuclear fuel was estimated to reach 103,500 MTU assuming that no new reactor is going to be built.

A paper on technical issues related to source term evaluation was presented by Yueting Chen (Framatome ANP). Several alternative models for estimating the source term were discussed and compared with the standard practice of using radionuclide solubility and the dissolution rate of the waste forms to constrain the source term. The contribution of Np-237 to the source term was presented by comparing Np solubility in terms of pure phases and solid solution, as well as that derived from spent nuclear fuel corrosion experiments.

The third paper that should be mentioned was presented by A. Whitehouse (Applied Photonics, UK). A description of laser induced breakdown spectroscopy was provided. In this technique, a pulsed laser is used as an excitation source for the generation of a plasma, which is analyzed spectrographically as a result of the emission of optical radiation by excited atomic and ionic species in the plasma. Several applications were presented in which waste forms or contaminants were characterized remotely through a lead-glass shield window or using a fiber optic.

Advances in the Treatment Technologies for Spent Fuel and High Level Waste Storage and Disposal

Three papers were presented in the session on Advances in the Treatment Technologies for Spent Fuel and High Level Waste Storage and Disposal. R. Rajamani (University of Utah) discussed results obtained from dry grinding of natural and depleted uranium samples using an RM-2 mill. Grinding in an RM-2 mill produces a two million fold increase in the number of particles and can be used for disposition of highly enriched uranium by blending with depleted uranium. Grinding provides a mixture that cannot be physically separated and hence reduces proliferation and safety risk.

R. Amme (University of Denver) presented results of his investigations on the use of vibrational shock compaction technology for the treatment of granular high-level waste. The presenter showed a blend of flyash, glass, and sand compacted using vibrational shock compaction produces solid samples that have good mechanical strength and passes toxic characteristic leaching procedure durability tests.

Disposal Containers

Five papers were presented in the session on Disposal Containers. Two of them were related to the design and materials for the engineered barriers of the proposed repository at Yucca Mountain.

In the first paper, presented by M. Anderson (BSC), the waste design for the license application was described. The suite of 10 waste packages designed to dispose the various types of spent nuclear fuels and high-level vitrified waste was briefly depicted, emphasizing the commonality in terms of materials (Alloy 22 for the outer container and Type 316 nuclear grade stainless steel for the inner container), shape, and closure lids. Differences between different methods of removing decay heat and preventing criticality were noted, as well as the internal configurations required for the various waste forms. A table listing the limiting event sequences for the preclosure period was presented, together with brief comments regarding the performance expected during the postclosure period for the various components of the waste packages. It was noted that the preliminary designs of only four waste package designs (21 pressurized water reactor fuel assemblies waste package with absorber plate, 44 boiling water reactor fuel

assemblies waste package, Naval Canistered spent nuclear fuel long waste package, and the codisposal short waste package for high-level waste and DOE spent nuclear fuel) will be included in the license application with the argument that these waste package designs are representative of the whole suite of designs.

The second paper related to the engineered barrier materials for the proposed repository at Yucca Mountain was presented by G. Cragnolino and dealt with studies conducted on the CNWRA on corrosion process that may affect the performance of waste package and the drip shield.

E. Smailos (FzK, Germany) presented a paper on the galvanic corrosion of Ti Grade 7 and carbon steel in a MgCl2-rich brine at 150 °C that deserves some comments. The main result of the work is that γ-radiation (at a dose rate of 10 Gy/hr) enhanced significantly the corrosion of carbon steel in the galvanic couple as a result of a change in the cathodic reduction reaction due to the generation of oxidizing radicals and stable reducible species such as hydrogen peroxide and oxygen. The corrosion of Ti grade 7 only increased slightly, but carbon steel experienced severe nonuniform attack.

Engineered Barrier System

In addition to a session on Engineered Barrier System—Design and Testing in which two papers describing the testing being conducted on a simulated breached drip shield and other engineered components at the DOE Las Vegas Test Facility, a session was devoted to Environments and Thermo-Hydro-Chemical Modeling of the engineered barrier system. In this session, there were several interesting papers.

G. Glascoe (Lawrence Livermore National Laboratory) presented the multiscale thermohydrological model developed for the proposed repository a Yucca Mountain taking into account thermal loading factors and in particular the influence of sequential waste package emplacement on the estimated temperature evolution.

Physical separation of different minerals precipitated during evaporation and the associated changes in water chemistry were discussed in a paper presented by D. Hall (University of Texas at El Paso).

C. Jove-Colon (Sandia National Laboratory) presented results of evaporation calculations approaching dryness using the EQ3/6 Version 8.0 code in which Pitzer model for the treatment of activity coefficient for concentrated electrolytes and the associated database are used.

Z.E. Peterman (US Geological Service) presented results of studies concerning the geochemistry of dust samples collected in the Exploratory Studies Facility at Yucca Mountain. The presence of relatively low Cl/Br ratios in the water soluble fractions of the dust was attributed to the tagging of construction water with LiBr. The dust was mainly composed of silicates and aluminates (accounted as SiO_2 and Al_2O_3), but the soluble anions and cations present (Cl, Br, NO_3, SO_4, Ca, Mg, Na, and K) were enriched in the finer fractions of the dust, reflecting the fact that they are derived from salts formed by evaporation of construction and native pore water.

The final paper of this session, titled Potential Importance of Fluoride to Performance of the Drip Shield was presented by C. Lin (NRC). The effect of fluoride in accelerating the uniform corrosion rate of Ti Grade 7 was presented as starting point of the analysis on the basis of experimental results obtained at CNWRA. By postulating several controlling process and adopting values for the parameters included in the analysis, it was concluded that drip shield failure, even for a high volumetric flow rate of water, was highly unlikely within 10,000 years, because it will require high water evaporation and dripping onto a very small area.

Spent Fuel and High-Level Waste Transportation

There were five presentations in the first session of Spent Fuel and High-Level Waste Transportation. The first paper was on transportation of encapsulated spent fuel to repository in Sweden and was presented by P. Dybeck of SKB-Sweden. In Sweden, the nuclear power plants and the potential repository sites are located by the sea. As a result, transportation by ship will be the preferred mode for transporting spent fuel from nuclear power plants to the selected repository site. P. Dybeck's presentation also discussed the various security and safety measures to be used for transporting spent fuel by ship.

The second paper of this session was on spent fuel transport and storage casks under extreme conditions and was presented by F. Lange of GRS-Germany. He presented the results of numerical and experimental studies conducted on spent fuel transport and storage casks under extreme conditions (e.g., cask drop and terrorist attack). The authors concluded that the effects of these conditions could be mitigated through robust designs of spent fuel storage and transportation casks.

The third and the fifth papers were on achieving success in spent fuel transportation campaigns in the United States and spent fuel transportation versus accepted societal practices. These presentations were made by C. Anne and C. Pennington of NAC International. The authors concluded that the success of spent fuel transportation campaigns depends on the success in convincing the citizens at the local and state levels through effective communications with them. The authors also showed that the radiological dose level resulting from spent fuel transportation is significantly lower than that resulting from radon gas at a given locality.

The fourth paper titled Concerns About the NRC's Package Performance Study. This paper was co-authored by R. Lambert of EPRI and R. Jones, an independent consultant. The presentation was made by R. Jones. The authors expressed their opinion that NRC package performance study under beyond design loads involves complicated technical activities based on many assumptions and simplifications that may be subject to contentions.

Storage Systems and Components

Two papers were presented in the second session on Storage Systems and Components. The first paper on the criticality safety of Hanford spent nuclear fuel storage was presented by the author S. Kessler of Fluor Hanford. His criticality study concluded that the stored spent nuclear fuel at Hanford is safe from a criticality point of view.

The second paper of the session titled Nondestructive Method to Quantify Water in Spent Peach Bottom Fuel Assemblies was also presented by S. Kessler of Fluor Hanford, although he was not a co-author of this paper. The determination of the amount of water present in a fuel

assembly is important to assess its criticality safety. S. Kessler presented a nondestructive method developed by the investigators at Mohr Associates to quantify water in spent Peach Bottom Fuel Assemblies.

Topics in Integrated Safety Analysis and Performance Assessment

A. Hedin of Swedish Nuclear Fuel and Waste Management Co, SKB, presented a paper titled, Integrated System Evolution Model for an SNF Deep Repository. This paper described a system model currently under development for the integrated treatment of several processes determining the long-term evolution of a KBS-3 repository. Hedin presented examples of the evolutions of the temperature in the buffer, the host rock temperature, the buffer chemical composition, canister corrosion, and the internal corrosion of an assumed defective canister.

S. Mohanty presented the paper titled, Independent Post-Closure Performance Estimates of the Proposed Repository at Yucca Mountain, Nevada. This paper summarized the NRC/CNWRA results from a suite of analyses of the performance of the proposed repository at Yucca Mountain. The presentation included the latest performance assessment results including the barrier capability; and the identification of models, parameters, and subsystems that have the most influence on repository performance through sensitivity and uncertainty analyses. The analyses were done to focus attention on the most critical parts of the estimation of post-closure repository performance.

D. Esh of NRC presented a paper titled, Alternative Conceptual Models and Performance Assessment. This paper explored methods to treat conceptual model uncertainty (e.g., alternative conceptual models) in performance assessment and discussed the advantages and disadvantages of various methods. The paper highlighted that any method selected for the treatment of model uncertainty in performance assessment should consider factors such as: computational efficiency, the number of reasonable alternative conceptual models, and the implications to risk of the alternative conceptual models. Both practical and hypothetical examples were presented to illustrate the strengths and weaknesses of various methods.

J.H. Kessler of EPRI presented a paper titled, EPRI Performance Assessment Results for the Yucca Mountain Repository. This paper described a recent assessment of the performance of the candidate spent fuel and high-level waste repository at Yucca Mountain, Nevada using EPRI's most recent version of its total system performance assessment code, IMARC-7. The paper provided an assessment of the overall technical suitability of the candidate high-level disposal facility at Yucca Mountain, and an assessment of which of the current DOE/NRC key technical issue agreements are of importance.

S. Mishra of INTERA Inc., Framatome ANP DE&S presented a paper titled, Testing for Input-Output Dependence in Performance Assessment Models. This paper discussed the application of two statistical techniques to evaluate the significance of input-output dependence for the general non-monotonic case. These techniques are: (i) chi-square test for independence to test the significance of association between sampled values of two random variables, and (ii) mutual information analysis to quantify the strength of association. The DOE Total System Performance Assessment was used as an example. The paper concluded that (i) a contingency table analysis of input-output data, using the chi-square test and entropy analyses, could help

identify variables that have statistically insignificant relationships with the output and (ii) these variables could then be used as candidates for pruning during the revision of abstracted models and/or parameters.

G. Freeze of Framatome ANP presented a paper titled, The Feature, Event, and Process (FEP) Database for Yucca Mountain License Application. He presented the recently completed approach to representing all features, events, and processes identified as being relevant to the Total System Performance Assessment-License Application analyses. He described the process of identifying the comprehensive list of features, events, and processes potentially relevant to the post-closure performance assessment and the structure and use of an electronic database for storing and retrieving screening information about the inclusion and/or exclusion of these features, events, and processes.

R. Rechard of Sandia National Laboratories presented a paper titled, Guidelines for Consistent Treatment of Parameter Uncertainty in Total System Performance Assessment-License Application. He described the process being used to assign probability distributions that represent parameter uncertainty and variability for the Total System Performance Assessment-License Application. For any one parameter, the process is meant to ensure that a distribution (i) represents the uncertainty realistically and (ii) is appropriate when used in the context of the Total System Performance Assessment-License Application system mode. One key strategy of the process implemented was to form a development team for each parameter. The team consisted of a team leader, a principal investigator knowledgeable about data available, and a modeling analyst. He used the distribution for an adsorption partition coefficient as an example to demonstrate the process.

O. Wantz of Université Libre de Bruxelles, Belgium presented a paper titled, In-Package Criticality Scenarios Development for the Belgian Spent Fuel Repository. He presented two long-term in-package criticality scenarios for the Belgian spent fuel repository concept. The two scenario sets were developed using two well-known systematic methodologies for scenario development: the bottom-up and the top-down approaches. Results showed that in-package criticality is only conceivable for largely disrupted systems. Based on the audience question, there appears to be a concern with the lack of consideration of the timing of various events in the logic tree approach used in their calculations.

B. Dasgupta presented a paper titled, Review Methodology for Pre-closure Safety Analysis of Proposed Geologic Repository. He described the regulatory requirements that mandate preclosure safety analysis for design and safe operation of the repository. He briefly described the PCSA tool that will be used during the review the DOE preclosure safety analysis. He also presented the methodology to be used by NRC to review the preclosure safety analysis.

B. Kienzler of Institut für Nukleare Entsorgung (INE), Germany presented a paper titled, Is Criticality a Matter of Concern for Gorleben?. He presented their investigation of several scenarios that could lead to criticality. They applied measured concentrations of U and Pu from corrosion experiments with spent UOX and MOX fuel together with model results to determine the degree of fissile material accumulation by different processes. The presence of chlorine in the geochemical environment of the disposal reduces the risk of criticality significantly. Selective enrichment of Pu onto corroded canister materials was analyzed and an upper limit for Pu adsorption was estimated. Results showed that in only extremely unrealistic case of selective sorption of pure 239 Pu, the vital prerequisite is met for criticality. However, co-precipitation of

new U/Pu mixed phases was expected. He concluded that the occurrence of criticality in a nuclear waste repository, particularly in rock salt, could be excluded to a high degree of confidence, because no mechanisms are known, which would enrich plutonium selectively under natural conditions.

M. Rahimi of NRC presented a paper titled, Estimating In-Package Criticality Impact on Yucca Mountain Repository Performance. He presented the CNWRA and NRC criticality consequence analysis results without the consideration of probability. Results indicated an order of magnitude increase in the peak expected dose for the transient criticality, compared to the base case, during the regulatory period.

S. Mohanty presented the paper titled, The Role of Solubility as a Barrier to Radionuclide Release. He presented the latest performance assessment calculations for determining the parameters that control the solubility limited behavior of radionuclides and the extent to which radionuclide solubility serves as a barrier to radionuclide release to the environment. The results showed that the causal relationship between solubility and radionuclide release is not simple. The degree to which a radionuclide is released to the environment depends on the complex interaction between the degree of waste form exposure to water, radionuclide half-life, and radionuclide initial inventory. Under some conditions, radionuclides with low solubility may not experience solubility limited release, whereas the release of radionuclides with high solubility can be solubility limited.

Meeting with Emmanuel Smailos

At the end of the Conference, NRC and CNWRA staff had a meeting with E. Smailos (FzK, Germany) to discuss results of the work conducted at FzK on the corrosion of Alloy C-4 (a Ni-16Cr-16Mo alloy) and Ti Grade 7 in high temperature $MgCl_2$- or NaCl-rich brine environments. Smailos reported that Alloy C-4 exhibited pitting corrosion in $MgCl_2$-rich brine after prolonged exposure at about 150 °C in the presence of γ-radiation at 10 Gy/hr. Although no pitting was detected in 12 months, pitting was observed after a 18 month-exposure.

IMPRESSIONS/CONCLUSIONS

This conference was organized with a variety of symposia on emerging and current topics. More than 450 attendees came from industry, academia, and government agencies. The participation at the meeting was an excellent avenue to present the work conducted at the NRC and CNWRA. Attending this conference also provided the opportunity to keep current with the topics relevant to the NRC high-level waste program.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

1. Participation in the organization and attendance at future International High Level Radioactive Waste conference is highly recommended.

2 Side discussions with representatives of the NRC Office of the Inspector General (OIG) indicated that they plan proactive involvement in the high-level waste program. It is suggested that a status of OIG activities be included as a regular item on the Yucca Mountain Team Meeting agenda, to ensure that all staff are aware of OIG activities related to the high-level waste program.

3. NRC and CNWRA management should monitor the implementation of the ITC, and assess whether staff would benefit from participation. Those interested are referred to www.ITC-School.org.

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S. Mohanty
Principal Scientist

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Date

W. Patrick, President
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P. Mackin
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