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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: 9th International High-Level Radioactive Waste Management Conference (IHLRWM)
Charge No. 20.01402.571

DATE/PLACE: April 29–May 3, 2001
Las Vegas, NV

AUTHORS: G. A. Cragnolino, W. Patrick, B. Sagar, V. Jain, S. Brossia, J.Winterle, A. Ghosh, B. Dasgupta, A.H. Chowdhury, S. Mohanty, C. Manepally, P. Mackin

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PERSONS PRESENT:

The conference was attended by approximately 560 people with approximately 40 percent international participation from Europa, Asia, and South America. The CNWRA was represented by 12 management and technical staff members and the NRC by 10 people.

BACKGROUND AND PURPOSE OF TRIP:

The main purpose of the trip was to attend the 9th IHLRWM, present papers, chair several sessions, and participate in the organization committee for the next conference to be held in the spring of 2003 in Las Vegas, Nevada.

SUMMARY OF PERTINENT POINTS:

The conference began on Monday, April 30 with an Opening Plenary on International Perspectives and continued through Wednesday May 2 with many simultaneous sessions and a poster session.

Opening Plenary: International Perspectives

L. Barrett [DOE Office of Civilian Radioactive Waste Management (OCRWM)] provided a general overview of the U.S. repository program, including an historical perspective and process/path forward. In light of recent allegations against the Yucca Mountain Project (YMP), he urged diligence in all written and oral communications to avoid the implication of bias. Key themes were "world class science," "investigative science," and "sound science."

R. Dyer (DOE YMP) provided a general overview of the YMP. A key concept he emphasized was the need to select a site that is "safe" rather than "best;" this was asserted to be both an appropriate and achievable goal for repositories throughout the world, since it provides flexibility in finding solutions to the waste problem. K. Hess [Bechtel-SAIC Corporation (BSC)] provided a management and operating contractor perspective after 2-1/2 months on the job.

C. Paperiello (NRC) provided a substantive survey of the state of the nuclear power industry, license renewal, interim storage, transportation, and disposal. He emphasized the demonstrable safety record of U.S. power generation and spent nuclear fuel (SNF) transportation (e.g., 1300 SNF shipments between 1979–1995 without any release). With respect to the repository, he highlighted (i) policy (not safety) differences between EPA and NRC, (ii) the commitment of the Commission to a formal licensing hearing, and (iii) the role of the Licensing Support Network (LSN) in providing access to all relevant information.

H. Issler (NAGRA, Switzerland) noted that the license application for a low- and intermediate-level waste (LLW/ILW) facility has been submitted and they expect a canton vote by the end of the year. The Swiss ZWILAG facility has been certified to store all categories of waste for the next 40 years. Issler stated that the waste management question must (i) be addressed "independent of the energy discussion," (ii) maintain options on implementation, and (iii) involve the public. He also reiterated the Swiss perspective that a siting decision must be based on a calculation that considers performance "until there is no serious risk," on the order of a million years.

Y. LeBars (ANDRA, France) gave an overview of the French program, including the leading roles of performance assessment and experimentation. The failure of the granite program in June 2000 was said to have resulted from taking a solely technical approach with a lack of public outreach. He expressed that the waste management community should "be humble," given the long time period involved, and noted in this context that France is now studying waste retrievability.

P. Nygards (SKB, Sweden) took a decidely philosophical approach in his remarks. His overview noted that deep geologic disposal has been accepted by most countries as both appropriate and suitably safe, and discussed why other approaches are not. The Swedish schedule calls for site selection by the end of 2001, detailed site investigation through 2007, commencement of operations in 2015 (emplacement of 10 percent of the SNF to conduct an evaluation), continuation on 2020 (subject to the result of the evaluation), and completion by 2050. Sweden relies on "three pillars" for its repository program: the bedrock, industrial use of the site and land, and public/societal elements. Nygards closed with a call for a common strategy among the nations: cooperative technical research, enhancement of the state of knowledge of all stakeholders, decision-maker meetings, cooperative interactions on methods for effective communication and dialogue with the public, and coming to agreement on "what is our business." He asserted that, in Sweden, they are in the environmental business, not the nuclear business.

Interactions with Regulators

R. Neill, former director of the New Mexico Environmental Evaluation Group (EEG) summarized the role EEG played in providing independent oversight of the Waste Isolation Pilot Plant (WIPP). He identified three things necessary for success of such a program. These are regulatory standards, full State participation, and recognition of risks and benefits. On the last point, he noted that society is not going to abandon ionizing radiation, but there needs to be an offsetting benefit for the risks incurred.

Presentations by P. Mackin (CNWRA), N. Coleman (NRC), and G. Cragnolino (CNWRA) (replacing T. Ahn as speaker) were well received.

Source Teem I: General Modeling Topics

In this session, co-chaired by G. Cragnolino, the first paper was presented by B. Kienzler (FzG, Germany), who described the combined modeling and experimental approach used in Germany for the source term. It is based on describing the concentration of soluble species for Pu, Np, and Am in CO_2-free brines (using a EQ3/6 database combined with the Pitzer approach for activity coefficients) as a function of the progress of the dissolution reaction for SNF or glass and comparing the results with experimental measurements.

The following papers were directly related to the YMP. A paper by E.E. Morris (ANL) described the PA approach used for ceramic and metal waste forms based on the use of GoldSim (the code included in the DOE TSPA-SR) with additional source terms for the two waste forms. Normalized cumulative release plots were used to compare these two waste forms with CSNF, DHLW, and DOE SNF for up to 100,000 yr using soluble radionuclides as indicator of the intrinsic dissolution of he waste form. T. Bauer (ANL) presented a related paper on experimental measurements of the rate of dissolution and release of metal waste forms made of stainless steel-zirconium alloys. R. Rechard (SNL) presented an overview of the various components of the waste form degradation model used in the TSPA-SR. C. Leigh (SNL) described the method used to estimate the radionuclide inventory for the TSPA-SR considering the various waste package designs and the different waste forms. E. Siegmann (Duke Eng.) discussed the various processes and models included in the cladding degradation model for TSPA-SR. The information presented in these last three papers is a summary of that contained in the corresponding DOE AMRs and PMRs.

Source Term II: Release Models

This was a particularly well-organized session, with all papers revolving around a single theme. The first three papers addressed unusual waste forms that are a small component of the expected inventory at the proposed repository. Fortner's (ANL) laboratory measurements on corrosion of metallic uranium fuel from N-Reactor identified both the sequence of corrosion and release rates associated with this unusual fuel. Experiments by Finn and her colleagues (ANL) on iodine release from fast-flux mixed oxide (MOX) fuels indicate that, from a release perspective, this may be one of the poorest waste forms. Corrosion of aluminide fuel under conditions anticipated at the proposed YM repository was the focus of the paper by M. Kaminski (ANL).

Papers by R. Rechard (SNL), R. Finch (ANL), and Y. Chen (Duke Engineering) focused on mainstream waste, and how solubility and radionuclide concentrations are measured and modeled. An important observation from this sequence of papers is that, over time, the modeled concentrations have increased while the laboratory observations have remained several orders of magnitude lower than those modeled. Reconciliation of this apparent divergence is needed. R. Codell presented the results of calculations by the NRC/CNWRA for three different models; the reader is referred to the authors or other published results for details of this paper. The final paper of the session reported on application of Secondary Ion Mass Spectroscopy (SIMS) to natural analog studies at the Cigar Lake and Gabon sites by M. Fayek (University of Tennessee) and colleagues.

Source Term III: Chemical Processes

In this session, co-chaired by S. Mohanty, the three initial presentations covered several aspects of water chemistry modeling for the YM project. The first presentation by J. Nowak (SNL) covered the modeling of the in-drift chemical environment. The second paper, presented by P. Domski (Duke Eng, Alburquerque),

described modeling in-package water chemistry, whereas the third one presented by Mehta (Duke Eng, Las Vegas), dealt with the implementation of the in-package water chemistry model in the TSPA-SR. In both cases, the main parameter discussed was the pH, which exhibits a significant decrease after the breaching of the waste package as a result of the corrosion of internal metallic components (i.e., steel), followed by an increase due to the interaction with the waste forms. As expected, the final pH was calculated to be higher for the codisposal waste package as compared to that for commercial spent nuclear fuel. There were discrepancies in the assumptions and results of both papers, which according to the authors reflected different stages in the modeling for the TSPA-SR rather than conceptual differences.

Secondary Minerals and Fluid Inclusions

This session dealt with the controversial topic of the origin and timing of water the led to the deposition of secondary minerals in the unsaturated zone at Yucca Mountain. Y. Dublyanski, a consultant for the State of Nevada, presented his argument that fluid inclusions in calcite minerals provide evidence that the repository horizon at YM has been inundated with hot water in the recent geologic past and that this water was derived from upwelling of saturated zone waters along deep-seated faults. Presentations by USGS staff argued in favor of a conceptual model that the source waters for secondary mineral deposits are of surface origin and that fluid inclusions indicating elevated temperatures are limited to mineral deposits that formed millions of years ago before the tuffs cooled. UNLV researchers presented an independent evaluation that is consistent with the conceptual model favored by USGS.

Panel Session: System Integration: System Engineering Versus Systems Engineering

This panel expended its time discussing fine points of semantic differences that appear to be mainly of academic interest (i.e., the "difference" between system engineering and systems engineering). This was troubling, given that all but one of the six participants were from the YMP. Although there was ample time for discussion, the inability of the panel to engage the audience through effective responses resulted in the audience losing interest after three questions. These questions probed for how the panelists would take a systems approach to multiple purpose casks that hold promise of reducing dose to operators, eliminating entire processes and associated accident sequences, and avoiding or minimizing costly repackaging at various stages.

National Programs II

This session was an eclectic mix of papers on various elements of three national programs. M. Jensen (SSI, Sweden) summarized the HLW disposal criteria developed for Sweden. Their program attempts to regulate within the context of the European Union mandate for sustainable development. M. Matthews summarized the ongoing international cooperative program at WIPP. At this site, cooperative research has been ongoing with 6–10 nations for nearly two decades. The author emphasized the mutual benefits of cooperation. These have been largely indirect, however, because most countries do not have salt repository programs. B. Reamer presented a discussion on how the NRC HLW regulatory program is being focused on licensing. He explained how this is being done within the historical context of NRC regulation, while incorporating Commission direction on risk-informed performance-based regulation. Readers are referred to available NRC position papers and previous training CNWRA and NRC staffs have been provided on this topic.

Plenary: Role of Uncertainties in the Development of a Safe Repository

Following opening remarks by session chair J. Kessler (EPRI), G. Hornberger (ACNW) provided the initial presentation. His principal theme was that the program is not "predicting" or "forecasting" performance, but "describing scenarios." More specifically, he stated that we "don't expect the base case" to actually occur, and called on those making calculations to use "best guesses" rather than the "gross conservatism" that he believes currently permeates those calculations. He closed by saying that computations should be used to gain insights and to communicate with the public. Although there is some appeal to his earlier statements, discrediting the calculations may undermine the ability to credibly communicate with the public.

T. McCartin (NRC) emphasized the need to go beyond the single performance assessment calculation to include evaluation of alternative models, intermediate results, parameter ranges and distributions, and the like. He emphasized how calculations using degraded and enhanced conditions and properties could be used effectively to address the question "What if I am wrong?" "What if the extremes of my distributions represent reality?"

D. Bullen (NWTRB) identified uncertainty as one of four key issues being addressed by the NWTRB. He highlighted (semantically) the differences regarding aleatory (i.e., randomness) and epistemic (i.e., lack of knowledge) uncertainties, but did not provide insights into how to (substantively) treat them differently. A key point was that the current practice of mixing optimistic, realistic, conservative, and unknown assumptions makes interpretation and decision-making very difficult.

W. Boyle (DOE) provided an overview of a DOE group he heads that is examining unquantified uncertainties.

P. Zuidema (NAGRA, Switzerland) addressed the topic of the panel in terms of management of uncertainty, and stated that PA is a "platform to manage uncertainties."

H. Riotte (OECD) reviewed the history of involvement of OECD in addressing uncertainty through various international groups, including the Performance Assessment Advisory Group (PAAG). He highlighted the importance of international peer reviews of all programs. In addition, he emphasized that decision makers need to know not just what the uncertainty is, but where it arises (e.g., what subsystems, structures, components, design elements, site features, etc. are most uncertain).

Source Term V: Ceramic Waste and Colloids

Four out of five papers planned for this session, co-chaired by V. Jain, were presented. Tom Fanning (ANL) presented a paper on ceramic waste form modeling in the Yucca Mountain Engineered Barrier System. Several papers were presented on this topic through out the conference. Ceramic waste form is used to encapsulate molten salt waste generated during the electro-metallurgical treatment process. The waste form is planned for disposal at the Yucca Mountain repository. In this paper, authors indicated that a recommendation will be made to use the HLW form model for the ceramic waste form in the performance assessment because the HLW form model conservatively bounds ceramic waste form behavior. A paper by Bill Ebert (ANL) on HLW degradation model in TSPA-SR discussed the revised model for HLW glass based on boron release instead of silicon release. This incorporates NRC/DOE CLST KTI agreement on the HLW form release rate determination.

Steve Alcorn (AEA) presented a paper on TSPA-SR model on colloids. His paper outlined the current model in the TSPA for colloid release through the engineered barrier system. Carol Mertz (ANL) presented a paper on use of Dynamic Light Scattering technique for characterizing sizes of the colloids. This is an in-situ method for analyzing formation of colloids in real-time. She indicated that presently there are limited standards for calibrating the equipment, which hinders the complete analysis of the experimental observations.

Issues for Regulatory Compliance and Performance Confirmation

The first presentation of this session was given by Mikael Jensen (SRPI-Sweden), who discussed an alternative approach to determine regulatory compliance. In the approach he presented, the technical issues (e.g., dose to public) are separated from the philosophical issues (e.g., what is an acceptable dose) and considered as separate questions. The purpose for this is that it is usually easier to demonstrate technical compliance than philosophical compliance. Bill Ford (NRC) then presented work done by the NRC in the ENFE and RT KTIs in regard to issue resolution. The KTI structure was discussed and the open/closed pending subissues were highlighted. He then rounded out the presentation with a discussion of the DOE/NRC technical exchange agreements and how the questions raised in the KTIs were being addressed by DOE. John Kessler (EPRI) gave a broad overview presentation on performance confirmation and what various activities this could entail. From his perspective, the performance confirmation plan should contain long-term laboratory testing as well as in-situ monitoring of conditions in the repository. He also mentioned that EPRI is now examining possible methods for confirmation of waste package performance. After reviewing many aspects of the DOE plan, he emphasized the need for DOE to initiate a more detailed consideration of performance confirmation methodologies soon. John Kessler's presentation was followed by Sean Brossia (CNWRA) who gave a presentation that examined possible approaches and methods to confirm waste package performance. This presentation was well received and generated several interesting questions from the audience. The final presentation was given by John Determan (INEEL) who helped to develop an expert system to review the data available on various batches of waste at INEEL.

Quality Assurance

This session chaired by R. Latta (NRC OR). D. Gwyn (Duke Engineering) presented a paper on the approach to risk-informed QA classification. He discussed the parallelism between a nuclear reactor and monitored geological repository (MGR), including some unique characteristics of the MGR. An overview of the DOE ISA process was presented. The DOE risk-informed classification process was also presented along with the rationale. R. Howard (Bechtel/SAIC) presented a paper on the "Grading Strategy for Data." R. Latta (NRC OR) presented the paper "Graded Quality Assurance in a Risk-Informed and Performance-Based Regulatory Environment" on behalf of L. Campbell (NRC) and T. Kobetz (NRC). He discussed the nuclear power plant experience with graded QA and its applicability to the proposed repository at Yucca Mountain.

Coupled Processes and Events II

Five papers were presented in this session. T.A. Buschek (LLNL) presented two papers on thermohydrologic issues at the proposed YM repository. He described the multiscale modeling approach developed at LLNL to analyze the thermal-hydrological problems at different scales. B. Ross (Disposal Safety) presented an alternative methodology to analyze the thermohydrologic problems at the proposed YM repository at multiple scales. His alternative method is based on the previous approach used by LLNL. Current method, as

presented by T.A. Buschek incorporate similar features. S.C. Blair (LLNL) presented some analysis results of the drift-scale heater tests. Correlation of the measurements made at one extensionmeter was correlated with the modeling results. J. Leem (Duke Engineering) presented thermal-hydraulic-mechanical analysis for the Viability Assessment (VA) design.

Preclosure Safety Case

Only three papers were presented in this session, which was co-chaired by B. Dasgupta. D.D. Orvis (Duke Engineering) presented the paper on the approach for performing an integrated safety analysis for the proposed repository. This paper describes the DOE strategy for developing an Integrated Safety Analysis (ISA) as part of the License Application (LA) for the Monitored Geologic Repository (MGR): (1) determining the specific requirements per the regulations in proposed 10 CFR Part 63 and NRC acceptance criteria for approaches and documentation per guidance provided in standard review plans and (2) defining a methodology for performing the ISA, including a means of dealing with the limited level of design detail available at the time of LA for CA. The paper adopted the guidelines for performing ISA in NUREG–1513. The safety strategy for the MGR will be based partly on deterministic principles and regulatory precedents, while much of the safety evaluation of surface and subsurface operations will be based on the techniques used in the probabilistic risk assessment: (i) internal and external hazards analysis, (ii) event sequence identification, (iii) frequency assessment, and (iv) consequence analysis /dose assessment.

A. Ghosh (CNWRA) presented some preliminary results of the sensitivity analysis carried out to assess the potential aircraft hazard at the proposed repository. Based on DOE data and some independent information, a preliminary assessment was carried out to estimate the crash hazard from DOE aircraft and aircraft chartered by DOE flying in route V105-V135 and military aircraft flying in the restricted airspace R-4808. The analysis shows that lack of site-specific information regarding number of flights per year and inadequate justifications for assumptions made in the DOE report regarding flight activities and mix of military aircraft produce a large uncertainty in crash hazard assessment. Information needs in both cases have been identified.

B. Dasgupta (CNWRA) presented details of a risk-informed, performance-based review methodology and a preclosure safety analysis software tool (PCSAT) that can be used by the U.S. Nuclear Regulatory Commission (NRC) to assess through independent analysis critical parts of DOE preclosure safety analysis (PCSA), identify SSCs important-to-safety, and assess whether the dose consequences to workers and the public are acceptable. The main hazards associated with the preclosure phase of this project stem from (i) the large inventory of radioactive wastes that will be progressively accumulated on site; (ii) the large number of surface processing operations that will be performed, many in parallel, to repackage the waste; and (iii) the subsurface operations involving transportation and emplacement of WPs in the underground drifts. The PCSAT pursues a systematic hazard analysis arising from the facility operations, identification of event sequences through determination of event frequencies, and performance objectives through dose consequence analyses. The PCSAT tool utilizes existing Integrated Safety Analysis methodologies and the tools under one overarching system that will review and keep track of DOE PCSA and help the NRC reviewers perform independent selected confirmatory analyses.

Both CNWRA presentations were well received.

Engineered Barrier System I

All four scheduled papers were presented in this session, co-chaired by G.A. Cragnolino. D.M. Jolley (Duke Eng.) presented a paper dealing with in-drift microbial communities at Yucca Mountain, in which the DOE approach to the consideration of microbial activity in terms of nutrient and energy considerations was summarized. Several assumptions regarding bacterial activities remain unanswered. K. Mon (Duke Eng.) presented the waste package degradation modeling used for the DOE for YM and the assumptions, process model abstractions, and source of data used in the WAPDEG code. This was a careful presentation in which the main assumptions were clearly delineated but the lack of sufficient data was evident. C. Forsberg (ORNL) had a presentation in which the case was made for the use of containers made of depleted uranium dioxide as a cermet in a stainless steel matrix. It was not clear, however, the advantages of such complex process for the disposal of various waste forms in terms of cost, although the current amount of depleted uranium is about 600,000 tons. The last paper in this session was presented by E. Smailos (FzK, Germany). The author discussed the influence of γ-radiation of the corrosion of Cu and Cu-Ni alloys as container material under reducing conditions in a NaCl-rich brine at 150 °C. A reduction of the corrosion rate induced by a 10 Gy/hr γ-radiation field was attributed to the improvement in the protective properties of the oxide film formed on the metal surface.

Engineered Barrier System II

All five scheduled papers were presented in this session, which was co-chaired by A. Chowdhury (CNWRA). D. Shoesmith (University of Western Ontario, Canada) presented two papers on engineered barrier issues. In the first paper, he described the predicted performance of waste package and drip shield on the basis of the models and assumptions used in the EPRI IMARC TSPA, Phase 5. In the second paper, Shoesmith discussed the approach adopted in the EPRI IMARC-5 to evaluate the effects of closure weld flaws on the propagation of stress corrosion cracks affecting waste package performance. J. Wintle (TWI, UK) presented the paper "Canister Sealing for High-Level Waste Encapsulation" on behalf of C. Ribton and R. Andrews. N. Francis (SNL) discussed the effects of drill and blast method of excavation on the long-term performance of the proposed repository at Yucca Mountain. C.W. Forsberg (ORNL) discussed how depleted uranium dioxide could be used as the particulate fill for waste packages containing spent nuclear fuel.

Poster Session

A session with about 12 posters was well attended. The posters covered a variety of topics. A visualization of performance assessment process models for the proposed YM repository through an animation as a function of time was very interesting and illustrative. The poster by Gdowski (LLNL) was a good presentation of the evaporation studies being conducted at LLNL to evaluate the environment in contact with the waste packages.

SUMMARY OF ACTIVITIES:

See preceding discussion.

CONCLUSIONS:

The conference was useful, in particular after a hiatus of three years because it provided a good forum for the presentation of most of the work conducted in the last few years. From a technical point of view, there was no significant news because most of the work presented by the DOE staff participating in the YM program was known to the CNWRA staff as a result of the review of TSPA-SR, PMRs, and AMRs. It should be noted that some of the sessions most heavily attended, with the exception of the plenary sessions, were those related to societal issues such as that on Stakeholder Involvement. It was also apparent that issues related to society and community responses to the disposal of radioactive waste, either positive or negative, were a more voiced concern in the presentations of the international participants.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

1. NRC and CNWRA experts in source term, radionuclide release, and performance assessment should carefully examine the growing disparity between analytical and numerical results of source term studies (see Source Term II: Release Models).

2. NRC and CNWRA staff involved in waste package degradation should review the models and assumptions incorporated in EPRI IMARC-5 code and analyze the results of the calculations that offer a strong support to the TSPA-SR results.

RECOMMENDATIONS:

NRC and CNWRA should continue to support this meeting by aiding in its organization, chairing sessions, and presenting papers. It should be noted that Budhi Sagar will be the Deputy Technical Program Chair for the next conference, and S. Mohanty and G. Cragnolino will be lead organizers for Integrated Systems and Engineered Systems, respectively.

REFERENCES:

The proceedings of the symposium in the form of a CD is available upon request from the authors.

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