CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Integration Group for the Safety Case, Engineered Barrier Systems (EBS) Workshop on Process Issues Jointly organized by the Organization for Economic Co-operation and Development/Nuclear Energy Agency and the European Commission
Project Number 20.06002.01.321; AI Number 06002.01.081.328

DATE/PLACE: September 14–17, 2004, Las Vegas, Nevada

AUTHOR: V. Jain

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PERSONS PRESENT: See attached list

BACKGROUND AND PURPOSE OF TRIP:

I attended the Integration Group for the Safety Case, Engineered Barrier Systems (EBS) Workshop on Process Issues. The workshop was organized by the Organization for Economic Co-operation and Development (OCED)/Nuclear Energy Agency (NEA) in cooperation with the European Commission (EC). The workshop was hosted by the U.S. Department of Energy (DOE), Office of the Civilian Radioactive Waste Management. This workshop was the second in the series of four workshops that are being conducted as part of the EBS Project. This workshop was not aimed to achieve consensus, but to develop a balance of concepts among repository programs. The workshop addressed not only longer-term post-closure conditions, which are generally more stable, but also the earlier more transitory stages of repository behavior during operations and shortly after closure. The workshop included a trip to the Yucca Mountain site.

SUMMARY OF PERTINENT POINTS:

The workshop was focused on the process issues associated with the EBS. The following four subjects were covered during the workshop.

1. Working Group A: Preclosure Processes
2. Working Group B: Thermal Management and Analysis
3. Working Group C: Alteration of Non-Metallic Barriers and Evolution of Solution Chemistry
4. Working Group D: Radionuclide Release and Transport

Plenary Session on September 15, 2004 started with a presentation from H. Umeki (NUMO, Japan) who discussed the scope and the objectives of the EBS project. This was followed by an overview presentation on the Yucca mountain program from A. Van Luik (DOE), and a presentation by C. Davies (EC) who provided an overview of EC programs. Next, two invited presentations were made on topics relevant to each working group. On September 16, 2004 the attendees joined one of the four groups to discuss process issues specific to their assigned Working Group. I participated in Working Group C: Alteration of Non-Metallic Barriers and

Evolution of Solution Chemistry. On September 17, 2004, Working Group results were presented by the team lead. Each Working Group examined the implementation of FEPS approach, quantification of uncertainty and variability, sensitivity analysis, and model validation and limitations to evaluate assigned process issues.

Plenary presentations for the Working Group A were given by H. Umeki (NUMO, Japan) and I. Puigdomenech (SKB, Sweden). Umeki highlighted that dynamic evolution of a repository and its environment could be caused by processes and events occurring throughout the construction, operations, and closure phases of a repository. These include chemical, thermal, hydrological, mechanical, and biological processes. A good understanding of coupling is needed for a reliable assessment of repository performance and for a developing a convincing safety case. Umeki briefed on the use of a Agent-Based Modeling approach for studying high-level interactions between repository components. This general multi-agent software was originally developed by the Santa Fe Institute (USA) for multi-agent simulation of complex adaptive systems. This software was used to understand: how macroscopic behavior of the repository and its environment depends upon the local interactions among agents (agent refers to a repository characteristic represented by data), and how repository can achieve its objective by resolving possible conflicts within its agents, and potential threats to the cooperative equilibria among the repository agents. Puigdomenech (SKB, Sweden) provided a synopsis of the near field processes discussed in an interim SKB safety report. He noted that processes occurring during operations phase could affect the state of repository at closure, and that the consequences of these disturbances should be evaluated in the safety case. Some of the processes that could influence the post-closure repository performance include hydrological disturbances due to draw-down or up-coning that could enhance colloid and bentonite erosion; geochemical disturbances such as microbial activity; and effects of grouting and other stray materials left behind on closure. Results of the Working Group A were presented by Umeki. Key issues during preclosure phase discussed in Working Group A were quality assurance and maintenance of materials, degradation of safety function of the host rock, and inclusion of stray materials (oil, equipment, metals, etc.) in tunnels during preclosure. Key messages resulting from the discussions of the working group were: (i) preclosure activities could influence evolution of EBS processes, and hence, the initial conditions of post closure. However, not many new processes are induced by preclosure activities, (ii) traceability is a key for managing precesses, (iii) simplifications made on preclosure processes should be verified in post closure safety assessment, (iv) non-identification of serious issues during preclosure, and (v) FEPs or something similar should be used to evaluate effect of preclosure processes on post closure performance.

Plenary presentations for Working Group B were given by L. Johnson (Nagra, Switzerand) and R. MacKinnon (SNL, USA). Johnson discussed the development of thermal criteria for SF/HLW repository in Opalinus Clay while MacKinnon discussed DOE approach to thermal management at the potential Yucca Mountain repository. Johnson provided an overview of the Swiss repository safety case and highlighted issues associated with the thermal hydrologic mechanical chemical (THMC) impacts on evacuated disturbed zone (EDZ) and bentonite. Specifically he indicated that heating may cause additional fracturing of the EDZ and could accelerate rock creep. Additional work is needed to establish a temperature criteria for the EDZ. Johnson also indicated that the temperatures in the bentonite barrier could have a peak value of 160 °C [320 °F] at the canister and 85 °C [185 °F] at the tunnel boundary that may change the post-saturation properties of the bentonite. Currently THMC modeling is limited to 100 °C [212 °F] because models are inadequate above this temperature. The barriers such as bentonite,

however, could still perform above 100 °C [212 °F]. The database needs to be expanded to explore maximum operating limits for barrier materials to allow to increase repository thermal loading above reference values. MacKinnon (SNL, USA) briefly described the US repository program. The multiscale thermohydrology model (MSTHM) represents repository foot print shape, location with respect to stratigraphy, and waste package sequencing. The model also includes repository-scale and temporal variability in percolation flux, uncertainties in percolation flux and thermal conductivity. Five cases are being documented in the TSPA-LA to cover expected range of thermohydrology conditions. Results of the Working Group B were presented by M. Apted (Monitor Scientific, USA). Key issues on thermal management discussed in Working Group B were elements such as heat loading per waste package, pitch between waste package, spacing between galleries, storage/cooling/ventilation periods, and choice of EBS materials that define thermal pulse and evolution of common features such as evolution of temperature of host rock and EBS components. Additional factors that effect the thermal management are environment, relative humidity, temperature, pressure, and time. An approach to thermal management in a safety case needs to be transparent and defensible. The criteria has to be relevant to the isolation strategy, repository concept, and potential impact on barrier performance. The criteria should be developed with inputs from design engineers, process engineers, and performance assessment staff, and should be flexible to allow changes as new data and site characterization information becomes available.

Plenary presentations for Working Group C were given by H -J. Herbert (GRS, Germany) and A. Van Luik (DOE). Herbert discussed alteration of non-metallic barriers and evolution of solution chemistry in salt formations in Germany and Van Luik discussed evolution of indrift environment in a potential Yucca Mountain repository. Herbert discussed performance of the backfill materials, its interactions with brines, and need for upscaled experiments. The self-sealing salt backfill consists of 80 percent magnesium sulfate, 10 weight percent halite, and 10 percent sylvite that on interaction with brines forms a barrier that has permeability and strength similar to host rock. In case of compacted bentonites the barrier performance depends upon long-term stability and swelling pressures. While compacted bentonites have excellent swelling characteristics in brines, their stability in brine solutions is a concern. Experiments indicate a significant dissolution and precipitation. Salt concretes consists of cement, crushed salt, and fly ash. These are fairly stable in brine environments. Van Luik described evolution of indrift environment during thermal pulse including role of deliquescence, dust, seepage water and their influence on EBS and waste form performance. Results of the Working Group C were presented by D. Bennett (Galson Sciences, UK). The working Group C examined the initial state of the EBS materials and the changes both physical and chemical that can effect the performance of a barrier. The changes could result from thermal effects such as peak temperatures and duration of heating; chemical effects such as reaction between barriers, with fluids; length of effects (transient or long-term); or extent of changes such as proximal, or distal. The reactions between barriers such as iron-bentonite-clay interactions, waste glass-bentonite-iron interactions, or crushed tuff-cement interactions could be important. It was noted that some chemical reactions are slow and difficult to study experimentally. Even though several modeling tools are available, it is difficult to validate these tools for expected repository conditions.

Plenary presentations for Working Group D were given by F. Plas (Andra, France) and J. Alonso (Enresa, Spain). Plas provided a brief overview of the French repository concept and discussed radionuclide behavior through EBS in Callovo-Oxfordian clay formation. The clay layer is 420 m deep and is 130 m thick. The French repository concept is based on horizontal placement of waste packages, surrounded by bentonite backfill. A metallic sleeve is provided to

allow retrievability. The methodology for safety assessment is based on Phenomenological Analysis. In this analysis, repository assessment is segmented by space and time. The spatial fracturing is based on repository components such as geological medium, surface environment, surface facilities, access shafts, and disposal zones. The time fracturing is based on operating period to 1 million years. The second presentation for Working Group D was delivered by Alonso. Enresa siting program was frozen in 1996. Currently limited activities are being conducted to provide a reference for research and performance assessment. Current repository concept consists of horizontal placement of carbon steel waste packages backfilled with bentonite. The presentation was focused on the sensitivity analysis to examine the changes in the temperature profile by changes in bentonite buffer width and gaps. Alonso also presented Goldsim modeling results, including sensitivity analysis, for radionuclide release and transport. Release to the biosphere was dominated by I-129 while release to the biosphere without going through geosphere is dominated by C-14 up to 20,000 years and by I-129 beyond 20,000 years. Results of the Working Group D were presented by L. Johnson (Nagra, Switzerland). Key issues discussed in Working Group D were release of radionuclides from waste forms and its retention within waste package and EBS. Also discussed were the issues with modeling of the interface between EBS and near-field host rock, effect of geometrical changes due to corrosion and gas production. Three examples were discussed by this Working Group. First was focused on uncertainty associated in C-14 inventory and speciation. The uncertainty in inventory results from –14 concentration in fuels while speciation uncertainty results from complexities of gas/dissolved pathways and effect of microbes on the generation of carbon gases. Second example was focused on radionuclide retention in waste package corrosion materials and the third was focused on bentonite performance. Key uncertainties for waste package corrosion were related to corrosion rate, structure and content of corrosion products, and changes in geochemical environment. The propagation of uncertainties were complicated by mix of models used in the performance assessment, for example, distribution function is used for carbon steel corrosion rate while an empirical expression is used for waste form dissolution.

Papers presented at the meeting will be published by NEA at a later date. However, a compilation of presentations made at this meeting are available and can be requested from the author of this trip report. A list of attendees and meeting agenda are attached for additional information. I can be reached by e-mail (vjain@swri.org) or phone at (210) 522 5439, if you would like discuss topics summarized in this trip report.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

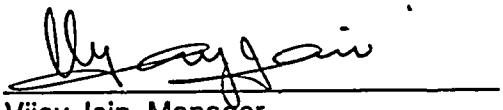
None.

RECOMMENDATIONS:

Participation in this workshop on the EBS project promoted international interaction and collaboration among experts who are responsible for engineering design, characterization, modeling, and performance assessment of EBS, as well as scientists working in disciplines relevant to EBS. It will also increase public confidence, and make NRC and CNWRA activities and decisions more effective, efficient, and realistic by gaining acceptance of international

and decisions more effective, efficient, and realistic by gaining acceptance of international experts. Future participation in these meetings is highly recommended.

SIGNATURES:



Vijay Jain, Manager
Corrosion Science & Process Engineering

9/30/04
Date

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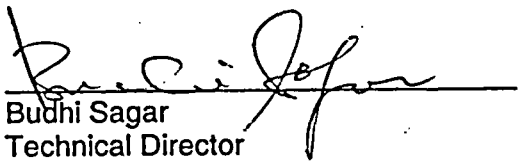

Budhi Sagar
Technical Director

10/1/04
Date

Attachments

Annex 1

AGENDA

1st day – 14 September 2004

VISIT OF THE YUCCA MOUNTAIN SITE

For those workshop participants will visit the Yucca Mountain Site on 14 September 2004, additional information will be sent separately regarding visitor badging and lunch choices.

06:40	Departure from Hotel to Yucca Mountain Science Center
07:00	Visitor Training and Badging at Yucca Mountain Science Center
07:45	Travel by Bus to Yucca Mountain
09:45	Presentations: current status of US-DOE Studies
10:15	Tour site and visit
14:30	Depart Yucca Mountain Site for Las Vegas
16:30	Arrive at Hotel / Possibility for Registration

15:20	Tea Break
15:40	**Characterizing the Evolution of the In-drift Environment in a Yucca Mountain Repository** *A. Van Luik (US-DOE-YM, USA)*
16: 20	**Radwaste disposal in France Radionuclides Behaviour through EBS for the disposal in the Callovo-Oxfordian clay formation: From Knowledge to Performance Assessment** *E. Giffaut and F. Plas (Andra, France)*
17:00	**Transport of Radionuclides in Spanish Performance Assessments** *J. Alonso, (Enresa, Spain)*
17:40	**Discussion**
18:00	**Close and end of the day 2**
19:30	**Dinner at:** **Gordon Biersch Brewery Restaurant** 3987 Paradise Road Las Vegas, Nevada 89109 Phone: +1 702 312 5247

4th Day - 17 September 2004

PLENARY SESSION

Chairperson: Abe Van Luik (US-DOE-YM)
Rapporteur: David Bennett (GSL, UK)

9:00	**Working Group Findings: Working Group A**
9:20	**Working Group Findings: Working Group B**
9:40	**Working Group Findings: Working Group C**
10:00	**Working Group Findings: Working Group D**
10:20	**Coffee Break**
10:50	**Discussion of Workshop Findings**
12:00	**Discussion of Recommendations for the EBS Project Forward Programme and Agreement of logistical steps (e.g., for publication of workshop proceedings).**
12:30	**Close of the Workshop**
12:30	**Lunch**

Engineered Barrier Systems (EBS) Workshop on Process Issues

Las Vegas, USA
14-17 September 2004

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