

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

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FOREIGN TRIP REPORT

Subject

Joint meeting of Probabilistic Safety Assessment and Management (PSAM 7) and European Safety and Reliability (ESREL 2004)

Dates of Travel and Countries/Organizations Visited

June 14 – 18, 2004; Berlin, Germany

Author, Title, and Agency Affiliation

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Background/Purpose

The objective of the conference was to provide a forum for discussing the latest developments in methodology and application of probabilistic and reliability methods in various industries. Of special interest in this edition of the conference was the use of novel methodologies in risk-informed safety management, taking into account economic and environmental aspects. The joint conference was aimed at promoting and enhancing communication, sharing of relevant experience, and integrating approaches on a truly global basis by bringing together leading experts from all over the world.

The authors presented four papers in the Radioactive Waste Management Symposium. Also, two authors, R. Codell and S. Mohanty, chaired sessions in the Radioactive Waste Management Symposium titled "Radioactive Waste – Managing Risk and Uncertainty" and "Radioactive Waste Management – Reliability Concepts." S. Mohanty was the co-coordinator of the Radioactive Waste Management and Decommissioning Track of the PSAM 7/ESREL 2004 Conference.

Abstract: Summary of Pertinent Points/Issues

On June 14-18, 2004, staff from the Division of High-Level Waste Repository Safety, Office of Nuclear Material Safety and Safeguards, and the Center for Nuclear Waste Regulatory Analyses, attended the Probabilistic Safety Assessment and Management (PSAM-7) conference held jointly with the European Safety and Reliability Conference (ESREL 2004) in Berlin, Germany. The conference covered many areas of probabilistic safety assessment and analysis techniques, particularly operational risk assessments. The participants presented four papers focused on technical issues related to licensing of the potential Yucca Mountain repository in a symposium devoted to radioactive waste management. The papers were entitled (1) "Role of Component Sensitivity Analysis in the Risk Assessment of a Large and Complex System"; (2) "The Interpretation of Risk and Sensitivity under the Peak-of-the-Mean Concept"; (3) "Sensitivity Analysis of an Engineered Barrier System Model for the Potential Repository System in the United States", and (4) "Probabilistic Risk Analysis Methodology for Preclosure Operations at a Geologic Nuclear Waste Repository." In addition, two of the participants chaired subsections of the symposium. There were five sessions in the radioactive waste symposium, with papers from representatives of the Czech Republic, Germany, Holland, Japan, South Korea, Sweden, Switzerland, the United Kingdom, and the United States. Interesting discussions arose in the treatment of post-closure scenario probabilities and consequences, treatment of conservative assumptions, risk communication, and problems related to site selection. Details are provided in the next section.

Discussion

The paper "Role of Component Sensitivity Analysis in the Risk Assessment of a Large and Complex System" discussed grouping components of the repository system at Yucca Mountain into subsystems. The subsystems are selected as barriers to contaminant release/transport in the system. In the sensitivity analysis approach, protective attributes of the "barrier" are mathematically degraded in the performance assessment model, and the effects of multiple combinations on the performance metric are analyzed. This approach is proposed to assess the contribution of components of the repository system to performance.

The paper "The Interpretation of Risk and Sensitivity Under the Peak-of-the-Mean Concept" discussed two commonly used performance metrics: the mean-of-the-peak dose and peak-of-the-mean dose. Quantitative comparisons suggest that using the peak dose from each realization can provide greater discriminatory power in sensitivity analyses. Some parameters, however, especially those that determine timing of the releases, should be interpreted carefully for the effect of their associated uncertainties on system performance. The paper discussed concerns about risk dilution arising from increasing bounds of distributions of not well known parameters, especially if these parameters affect the timing of peak dose within a realization.

The paper "Sensitivity Analysis of an Engineered Barrier System Model for the Potential Repository System in the United States" discussed a methodology to perform sensitivity analyses on outputs that are functions of time applied to the Yucca Mountain system model. The paper presented a novel technique known as the Partitioning Method to perform point-metric sensitivity analyses. The partitioning method was complemented with the principal component decomposition to perform sensitivity analyses of radionuclide release rate as a function of time. The paper discussed the identified parameters that control release from the engineered barrier system.

The paper "Probabilistic Risk Analysis Methodology for Preclosure Operations at a Geologic Nuclear Waste Repository" discussed a probabilistic risk methodology capable of calculating total facility risk and propagating uncertainty. The methodology includes combinations of different initiating events for identifying the likely accident scenarios and consequences as well as the largest contributors to the total risk. An example problem was presented to show how the methodology can rank structures, systems, and components by their importance with respect to risk. Risk insights gained from using the methodology provide valuable information for highlighting aspects of facility design, applying quality controls, and focusing regulatory reviews.

Most papers in the conference dealt with active, operating systems such as industrial processes, nuclear power, and transportation. Some papers were of broader interest, dealing with mathematical methods for assessing risk, and analyses of uncertainty. The papers of most interest to the NRC and CNWRA participants were concentrated mainly in the four sessions on waste management. Papers by other authors that generated interesting discussions are briefly mentioned. Other presentations were equally informative and interested people should contact conference attendants for copies of proceedings.

Björn Dverstorp from the Swedish Radiation Protection Authority presented the paper "Management of Uncertainty and Risk in Safety Cases for Radioactive Waste Disposal: Summary of an OECD/NEA Workshop held in Stockholm February 2004." This paper is a good reference comparing different safety assessment approaches adopted by various countries, including the USA. There were similarities among programs related to transparency and traceability in the safety cases presented to decision-makers and stakeholders.

Klaus-Jürgen Röhlig from Gesellschaft für Anlagen- und Reaktorsicherheit (GRS, Germany) mbH presented the paper "Long-term Safety of Final Repositories: Experiences concerning the Role of Uncertainty and Risk in Assessments and Regulations." The paper discussed approaches for defining regulatory protection objectives currently pursued for a repository in Germany. It is proposed that the annual dose should not exceed 0.1 mSv [10 mrem] for the expected condition and should not exceed 1 mSv [100 mrem] per year for high-consequence scenarios without probability weighting (which is consistent with the German advisory committee position that 1 mSv [100 mrem] per year is the maximum acceptable dose from any scenario). The author discussed the attempts by the Nuclear Energy Agency (NEA), Probabilistic Safety Analysis Group (PSAG), to treat all uncertainties and degrees of belief in alternative scenarios and models in one aggregate analysis that produced a single risk number for compliance purposes, but conceded that this is not generally done in practice. Röhlig concluded that (1) scenario analysis is essential and results of each scenario must be presented individually; (2) subjective choices should not be hidden from view and to do so reduces clarity and traceability; (3) quantification of likelihoods for scenarios is questionable; (4) combining high-probability/low-consequence scenarios and low-probability/high consequence scenarios is confusing and can produce an ethical dilemma; and (5) very low probability scenarios should be analyzed and presented separately from the full probabilistic assessment.

Thomas Flueler from the Swiss Federal Institute of Technology presented "Long-term radioactive waste management: challenges and approaches to regulatory decision-making" that describes the Swiss experience with licensing strategies. He commented that the "decide-announce-defend" approach has not been successful. Technical constraints must be in line with the agendas of stakeholders. While today's public wants safety, future generations are not decision makers, and may not welcome past obligations and land-use restrictions. Most likely, future generations will want control in the event of serious failures. Regulatory bodies must accept the value of being learning organizations, and should adapt a "propose-learn-share-decide" strategy. A generic design was discussed where most of the waste would be emplaced in the main facility with engineered backfill, while a smaller amount of remaining waste would be placed in a pilot facility for long-term monitoring. No time limit has been set for the demonstration of safety. If deemed necessary, such a time limit would be determined by the regulator.

Geoff Vaughan of Nuclear Installations Inspectorate (United Kingdom) presented "The Role of Probabilistic Safety Analysis in Radioactive Waste Management - A UK Regulatory View." The paper communicated the current UK approach of temporary on-site storage for intermediate- and high-level water for about 100 to 150 years while permanent disposal options are investigated further and prepared for. The paper introduced the concept of "hazard potential" for waste as defined by the product of factors for toxicity, physical form, and chemical reactivity. It was recommended that the probabilistic safety assessment balance the preclosure risks (to both workers and the public) and the postclosure risks (to the public) as a total accumulated risk posed by the facility. This total accumulated risk can provide insights for making decisions on different action options or facility designs/operations.

Leon Reiter of the Nuclear Waste Technical Review Board (USA) presented "What role for performance assessment?" While performance assessment is necessary for determining compliance with regulations, the U.S. experience revealed both strengths and weaknesses, and performance assessment alone is not sufficient for compliance determination. Performance assessment should be one component of the safety case that also should include simplified

calculations, multiple barriers and natural analogues. Furthermore, performance assessments should reveal why the repository would comply (or not), the uncertainties and assumptions that have the largest influence on results, and the robustness of the assumptions and results.

J.W. Schneider of the National Cooperative for the Disposal of Radioactive Waste (Switzerland) presented "Deterministic and probabilistic analysis supporting the safety case for a proposed deep geological repository in Opalinus clay in northern Switzerland". The Swiss have two concepts for nuclear waste disposal, one of which is in clay. Their current safety case uses a mix of deterministic and probabilistic analyses. They use hypothetical "what if" cases to test the repository robustness even though there is no evidence that such events can occur. They use deterministic analyses where there are wide ranges between predicted results and the regulatory limits. However, they also use probabilistic analyses even in these cases so they can generate sensitivities of the results to parameter variations. Quantitative analyses are complemented by qualitative discussions of system performance based on evidence other than the direct calculations.

Allan Hedin of the Swedish Nuclear Fuel and Waste Management Company (SKB) presented "Methodology for risk assessment of an SNF repository in Sweden". Sweden is investigating two candidate sites and running total system performance assessments to demonstrate compliance and provide feedback to developers. They appear to be using a similar method to the NRC-stipulated risk measure based on the peak of the mean dose. They plan about 10 separate scenarios with some variants. Some scenarios will be deliberate overestimates for the purpose of risk assessment and others will try to better quantify risk where more data are available. They distinguish between aleatory (irreducible variability in parameter inputs) and epistemic (lack of knowledge) uncertainty wherever possible. They will use sensitivity analyses to determine where improvements in risk analysis are warranted. The author recognized some of the same points in the paper by Codell, Esh, and Mohanty, "The Interpretation of Risk and Sensitivity Under the Peak-of-the-Mean Concept", that a criterion based on risk as a function of time can lead to "risk dilution", but that this is inherent in risk analyses. A comparison of the mean of the peak doses to the peak of the mean dose was proposed for assessing any potential effects from risk dilution.

Ian McKinley of National Cooperative for the Disposal of Radioactive Waste (Switzerland) presented "Assessment of operational-phase safety of deep geological repositories for radioactive waste." This paper highlighted the operational phase risks for the proposed Japanese high-level waste repository. He commented that the real risks of a repository are likely to be in the operational phase rather than in the post-closure phase. The operational risks are dominated by reliability of equipment and human error, while the post-closure hazards are mainly from small radiological exposures unlikely to be high enough to cause actual human fatalities or even significant increases in doses. Accidents during operation could cause loss of public acceptance. While careful desk audits of equipment operation are helpful, some complex processes such as remote waste emplacement might require full-scale testing.

Hiroyuki Umeki of the Nuclear Waste Management Organization (Japan) presented "Alternative repository design options for HLW disposal in Japan." Japan is calling for volunteer municipalities to host the Japanese site, emphasizing the need for public acceptance. Because there have not been any volunteers yet, alternative models for a variety of potential sites must be considered. Only certain areas of the country are suitable for a repository because of active tectonics. The volunteer host sites must be evaluated on a list of site-specific factors that cover such things as land use, mechanical and thermal properties of the host rock, hydrogeology, the geosphere/biosphere interface, and site geochemistry. The Japanese authorities hope to

compile a range of suitable sites by this process and to choose the best from among the range for further evaluation.

Impressions/Conclusions

Attendance of the conference fulfilled the objectives of keeping up to date with methods to support development of risk insights and use of risk information for decision making. International prospects for nuclear power generation in the future were discussed in the conference. Important contacts with representatives of international programs were established that will facilitate further exchange of information. Participants in the Radioactive Waste Management and Decommissioning track attended all five technical sessions, generating fruitful discussion on all presentations. Future attendance to PSAM/ESREL conferences is recommended.

Some pertinent points presented during the conference are summarized next.

- Some countries have decided to disaggregate postclosure scenario probabilities and consequences and evaluate each scenario separately (rather than compute the total risk from all credible scenarios for regulatory compliance).
- Probabilistic safety assessments for international nuclear facilities have used conservative assumptions for more likely scenarios and best estimates for less likely scenarios.
- The confined space associated with underground operations was viewed as a tremendous challenge for emplacement operations.

Pending Actions/Planned Next Steps for NRC

None.

Points for Commission Consideration/Items of Interest

Germany is currently considering to propose the following dose-based regulatory standards: (1) The annual dose should not exceed 0.1 mSv [10 mrem] per year for the expected condition and (2) the annual dose should not exceed 1 mSv [100 mrem] per year for high-consequence credible scenarios without probability weighting. The standards are consistent with the German advisory committee position that 1 mSv [100 mrem] per year is the maximum acceptable dose from any credible scenario.

Attachments

Attached is the technical program of the conference.

"On the Margins"

None.

Signature and Date



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7/22/2004
Date

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Date



Roland Benke, CNWRA

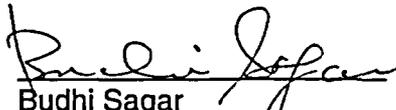
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