

# CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

## TRIP REPORT

**SUBJECT:** The First Asian and Oceanic Congress for Radiation Protection (AOCR-1)  
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**DATE/PLACE:** October 20–24, 2002  
Seoul, South Korea

**AUTHOR:** Narasi Sridhar and Wes Patrick

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### **PERSONS PRESENT:**

Approximately 450 representatives of radiation protection professional societies, individual researchers in a spectrum of engineering and scientific fields, and government agency leaders and staff attended the conference. From the Center for Nuclear Waste Regulatory Analyses (CNWRA), Dr. Narasi Sridhar attended on behalf of the U.S. Nuclear Regulatory Commission (NRC) and Dr. Wesley C. Patrick attended on behalf of Southwest Research Institute® (SwRI®). A list of participants is available from the authors.

### **BACKGROUND AND PURPOSE OF TRIP:**

The First Asian and Oceanic Congress on Radiation Protection (AOCRP-1) took place October 20–24, 2002, in Seoul, Korea. The AOCRP-1 was hosted by the Korean Association for Radiation Protection, Asian and Oceanic Association for Radiation Protection, and International Radiation Protection Association. In addition to various organizational meetings by the participating radiation protection associations, the AOCRP-1 featured reports from each participating nation, a series of keynote addresses, invited presentations, topical presentations, panel discussions, and poster sessions. The conference covered all aspects of radiation protection, including the effects of non-ionizing radiation, such as the electromagnetic fields arising from power lines and electronic devices. Of special relevance to the repository program were the sessions devoted to waste management and risk perception/public acceptance. The purpose of the trip was to present a paper in the AOCRP-1 on the CNWRA activities relevant to the evaluation of repository safety and a poster on the methodology for long-term calculation of container life. Additionally, the Korean Atomic Energy Research Institute was visited as part of the conference tour.

### **SUMMARY OF PERTINENT POINTS:**

The scope of AOCRP-1 was very broad. Radiation protection was addressed from the perspectives of commercial nuclear power production, research and test reactors, radioactive waste management, facility decommissioning, and nuclear medicine. As a result, topics of interest to all three principal offices of the NRC were addressed. Of special importance to the repository program were the sessions on waste management and risk perception.

N. Sridhar (CNWRA) presented a poster titled "Life Prediction of Container Materials for High-Level Nuclear Waste Repository." W. Patrick (CNWRA) presented an invited paper titled "Evaluation of Repository Safety," and co-chaired the second session on Radioactive Waste Management (note that participation by Patrick was not sponsored by NRC, but the presentation was approved). The poster and oral presentations were well attended and generated good discussion.

Following the formal congress, technical tours took place at the Korea Atomic Energy Research Institute, Korea Electric Power Company Nuclear Fuel Company, and Korea Institute for Nuclear Safety. These tours and the ensuing discussions indicated that South Korea is placing emphasis on advanced reactor designs and low/intermediate level waste disposal. The high level waste disposal program is on an extended timetable and, therefore, does not have the funding priority of the other two programs.

## ACTIVITIES

### Keynote Addresses

The AOCR-1 began with three keynote lectures. S-Y. Yoo, President of the Korean Association for Radiation Protection emphasized the importance of radiation protection in the arena of nuclear power production, which he cited as essential to sustainable growth throughout the Asian and Oceanic region, as well as to reduction of green house gas emissions. He identified terrorism as the "first threat" to be addressed with respect to radiation sources, which are seeing widespread dissemination to even under developed countries as industrial and medical uses expand.

Continuing on this theme, H. Ishiguro, Chairman of the Asian and Oceanic Association for Radiation Protection, emphasized the central role of infrastructure in radiation protection. He also called for improved international standardization, while recognizing that each country has its own "context" for implementing such standards.

G. Webb, President of the International Radiation Protection Association, was the final keynote speaker. His central theme emphasized the need for radiation protection professionals to become more extensively and personally involved in their profession, particularly through the national societies. He also called for expansion of both national and regional associations to facilitate standardization and implementation of best practices. International Radiation Protection Association intends to develop a Code of Ethics, building on those of the U.S., UK, Australia-Asia, and Canadian practices. Webb also challenged participants to press for a stronger role of International Radiation Protection Association in the International Council on Radiation Protection, particularly by participating in standards development and commenting on draft International Radiation Protection Association in the International Council on Radiation Protection standards. He closed his remarks stating that accidents and terrorism will be the twin focal points for the next century. Effectively meeting this challenge will require (i) prevention (by physical and administrative means), (ii) response preparation, and (iii) response to events. The International Radiation Protection Association website should be consulted for additional information.

## Country Reports

Country reports were provided by senior representatives from Korea, Australia, China, India, and Japan. Summaries are available in the proceedings and as a CD-ROM.

## Special Lectures

A.J. Gonzalez of the International Atomic Energy Agency presented a special lecture on **New Horizons in Radiation Protection**. His opening volley in this 240-slide 40-minute lecture was that the longstanding linear no-threshold debate is of strictly academic interest. He argued from the perspective that the range of doses of interest to the linear no-threshold model are all below background, which is not of regulatory concern and, consequently, irrelevant. Gonzalez identified a number of current issues under consideration by the International Atomic Energy Agency. These include:

- Regulatory infrastructure, particularly, the need to determine the scope of regulatory control simply and comprehensively;
- Safety and security of radioactive sources, recognizing that they are abundant, orphaned from any control, widely available in states of the former Soviet Union, not well secured, readily amenable to malevolent use, and such use has demonstrably severe consequences;
- Safety of radioactive waste, with a call to be responsive to International Atomic Energy Agency guides, action plans, and principles (International Atomic Energy Agency peer reviews were cited as particularly useful/helpful to national programs);
- Control of discharges into the environment, particularly the evolution to emphasizing protection of the individual versus collective dose;
- Treatment and control of radioactive residues from industrial processes, uranium enrichment (i.e., depleted uranium), nuclear weapons testing, etc.;
- Decommissioning of nuclear facilities;
- Implementation of a truly international radiation safety regime comprising (i) legally binding conventions, (ii) international standards, and (iii) provisions for application of those standard.

A.C. Upton (Consortium for Risk Evaluation with Stakeholder Participation; University of New Jersey) followed with a considerably more deliberate and thoughtful discussion of public and professional interest in the linear no-threshold model. Consult his paper for his perspectives on cellular and DNA-level responses to ionizing radiation. Both mutagenic and carcinogenic responses were explored.

The third lecture was presented by G.F. Knoll (University of Michigan). He gave a detailed technical account of the historical and ongoing development of digital and integrated circuit technologies in radiation spectroscopy.

The final special lecture was by R.H. Clarke (Chairman, International Council on Radiation Protection) on Progress by International Council on Radiation Protection in the Development of Radiological Protection for the Start of the 21<sup>st</sup> Century. Clarke focused on the major transition from collective dose to individual protection, noting that this shift had nothing to do with new scientific insights, but was driven by social changes that give increased emphasis on the rights of individuals versus society at large. The aims of the International Council on Radiation Protection going into this century are (i) developing a single, comprehensive set of recommendations building on the post-1990 standards; (ii) primarily emphasizing individual protection; (iii) establishing consistent "protective action levels;" (iv) clarifying dosimetric quantities; and (v) considering changes that may be needed to provide protection to the environment (beyond human radiation protection).

### Risk Perception and Public Acceptance (Session T-3)

Two papers by S. Osaki and H. Ogata (Kyushu University) explored experience communicating risk in the context of natural background radiation. A key point is that their study found no relationship between natural background dose and total mortality from cancer, while noting mortality in men was about twice that of women in their study group. Osaki suggested developing and distributing "watch type" dosimeters to the general population near nuclear facilities to both develop a familiarity with radiation dose and provide a basis for identifying perturbations in the event of a nuclear incident.

Two papers by Y-P. Kim (Korea University) and B-S. Choi (Seoul National University) explored how risks are perceived based on a survey of the general population and an informal elicitation of expert opinion. Their study arbitrarily set automobile safety as the "average" on their risk index. Consistent with previous studies in the US, radioactive waste and "radiation leakage" were judged by the surveyed public to present the highest risk; nuclear power did not rank as high. The transportation industry was ranked in the lowest range of risk. The study did not appear to explore principal factors affecting perception of risk (e.g., the earlier work of Slovic and others), nor did it compare public perception of risk with absolute (i.e., objectively measured) risk. Furthermore, although automobiles were set as the "average" in the risk index, 20 to 21 of the 25 risk categories were compressed into the above average range, raising questions about the survey design.

### Radiation Protection in Nuclear Facilities (Session T-4A)

This session featured six papers addressing radiation risk in nuclear power reactors, changes to the next-generation designs to reduce exposures, research reactors, and decommissioning. Of particular interest was the paper by T. Yamamoto (Osaka University) on using virtual reality and web-based training to enhance skills in both radiation protection and in operational tasks (i.e., to reduce exposure time, human errors, etc.). Y-I. Song (Korea Hydro and Nuclear Power Company) described efforts to "optimize" occupational exposure during a power plant outage. A formal optimization study was conducted using a cost-benefit analysis technique adopted from International Atomic Energy Agency guidelines.

### Radiation Effect (Session T-1C)

One of the more interesting presentations in this session was the work of T. Matsuura (Radiation Education Forum) on the existence of a threshold in the dose-response relationship

from the epidemiological data of atomic bomb survivors. His premise is that adding a baseline "chronic dose" to the reported "acute dose" commonly used in studies of linear no-threshold leads to a conclusion that there is an approximately 0.32 Sv [32 rems] threshold. The work appears to focus on so-called "not in city survivors" (i.e., those who were not in Nagasaki and Hiroshima when they were bombed but returned shortly thereafter). It seems that anecdotal reports played a significant role (principally assertions of hair loss at 8 Sv [800 rems] versus the more commonly used 30 Sv [3000 rems] level), which members of the audience questioned because it could shift the entire analysis and invalidate the conclusions drawn by the speaker.

#### Radiation Protection in Nuclear Facilities (Session T-4B)

M-C. Wong (Hong Kong Observatory) described efforts to implement a public education program to support nuclear accident contingency planning. The principal lesson learned was that (at least in that society) static displays were not effective and were very infrequently visited. Web-based systems appear to be much more attractive and effective, particularly with the younger generation. They have developed a three-tier approach to facilitate access to a level of detail commensurate with interest. Although the overall approach appears to be useful, some of the examples Wong presented were technically incorrect and sensational (e.g., if a user answered "95 percent" to a question on level of enrichment of U-235 in a reactor, the web page blew up).

B. Yatsalo (Obninsk Technical University of Nuclear Power Engineering) presented an excellent paper on Assessments of risk indices and decision-making support within a risk based land management and sustainable rehabilitation of radioactive contaminated territories. The study focused on a large region that was contaminated as a result of the Chernobyl accident. Researchers at Obninsk developed a comprehensive geographical information system of pertinent geophysical, geographical, land form, land use, vegetation, nuclide-specific contamination, etc. that supported the decision-making process. The approach parallels the concepts the CNWRA has promoted with regard to the Tank Waste Remediation System, West Valley Demonstration Project, and Yucca Mountain Project.

#### Radiation Protection of Public and Environment (T-6A)

An invited paper by T. Mikkelsen (Riso National Laboratory, Denmark) summarized the European program of atmospheric dispersion modeling. This effort includes data assimilation, forecasting dispersion of contaminants, and comparing model results with large scale experiments. The validation studies used routine Ar-41 releases from an air-cooled research reactor. The authors reported very good agreement between modeled and measured results.

H-J. Choi (Korea Atomic Energy Research Institute) reported on their work estimating tritium concentrations in groundwater near nuclear power plants. Their calculations used a dynamic compartment model.

#### Radioactive Waste Management (T-8A)

The first session on radioactive waste management dealt primarily with radiation sources, but included presentations on reactor decommissioning the back-end of the fuel cycle, as well. Of particular note was the presentation of S-Y. Chang and J.S. Song (Chosun University), who reported on a methodology for evaluating the economic and environmental aspects of various

options facing South Korea to close their fuel cycles. South Korea has 16 Pressurized Water Reactors (PWR) and 4 Canadian Deuterium-Uranium (CANDU) reactors, the latter generating higher volumes of waste. The costs associated with direct disposal of spent fuels, reprocessing of PWR fuels and disposal of wastes, and the Direct Use of PWR fuels in CANDU reactor (referred to as "DUPIC") were compared.

The reference container concept for the proposed Korean high-level waste repository was discussed in a presentation by Choi et al. (Korea Atomic Energy Research Institute). They performed calculations on the mechanical failure of different container configurations using finite element code NISA. Included in the calculations were hydrostatic and swelling stresses from the bentonite buffer. In this analysis, an arbitrary fault displacement of 10 cm was also included. A multi-wall container with a cast iron insert surrounded by either copper or an unspecified Ni-base alloy (with generic mechanical properties) were considered in the calculations. The analysis indicated structural stability with a cast iron cask 112 cm in diameter with a 15 cm wall thickness.

#### Radioactive Waste Management (T-8B)

The second session on radioactive waste management was co-chaired by T. Ikeda (JGC Corporation, Japan) and W. Patrick (CNWRA, U.S.). The session began with Patrick presenting an invited paper on Evaluation of Repository Safety. The paper reviewed the regulatory context for US repository development, the basic approach to repository safety and performance assessment, and the methods used by NRC to independently evaluate pre-closure safety and post-closure performance assessment.

T. Kato (Japan Nuclear Cycle Development Institute), in collaboration with Quintessa Ltd. (UK) and EnviroQuantiSci, Ltd. (UK), summarized their work on biosphere modeling, as used in the "H12" safety assessment for proposed high-level waste disposal in Japan. In addition to basic dose pathways relevant to the proposed repository at Yucca Mountain, Japan considers both river and marine pathways, and the associated food products. They also considered the specific agricultural practices and dietary habits of the Japanese population.

The SAGE 1.0 computer code was the subject of a presentation by J-W. Park (Korea Hydro and Nuclear Power Company). The code was specifically developed to address low- and intermediate-level waste disposal. Key features include a probabilistic framework, a graphical user interface to ease use, use of Latin Hypercube Sampling, and calculation of a cumulative distribution function for peak dose. The work to date appears to rely on available data from the literature, mainly for low-level waste; source term information was not presented for intermediate level wastes. In addition, disruptive events are not included in the model.

Studies of migration behavior under reducing conditions was the topic of a presentation by A. Kitamura (Japan Nuclear Cycle Development). These laboratory studies used batch techniques. Discussions suggest that the laboratory and modeling efforts are not integrated at this stage of their program.

The final presentation of the session reported on work by Y-J. Kwon and colleagues at the Korea Atomic Energy Research Institute. This study examined structural stability of a reference design disposal container comprising a cast iron inner canister and a corrosion-resistant outer barrier. Elasto-plastic modeling was used. Evaluations included cases of constant pressure

from the bentonite backfill, as well as an assumed 10-cm fault offset evaluation. Their study indicated adequate structural integrity for the conditions considered.

### Poster Sessions

N. Sridhar presented a poster at AOCRP-1 on behalf of NRC titled "Life Prediction of Container Materials for High-Level Nuclear Waste Repository." Several poster presentations were of interest to a number of NMSS programs. Posters 6-29 and 6-30 by Suh et al. (Korea Atomic Energy Research Institute) discussed a Lagrangian particle model for calculating long-range atmospheric dispersion of radionuclides. The model results compared favorably with Gaussian plume and puff models. Jeong et al. (Korea Institute of Nuclear Safety) (Poster 8-5) presented the Korean approach to waste acceptance for a near-surface disposal repository. Cheong et al. (Korea Institute of Nuclear Safety) (Poster 8-7) discussed the radiological impacts arising from the recycling of steel scraps resulting from nuclear fuel cycle facilities.

### Facility Tours

A tour of the Korea Atomic Energy Research Institute and Korean Electric Power Company fuel fabrication facilities was arranged by the symposium organizers. The tour included a presentation of the Korean advanced reactor development program. Additionally, N. Sridhar visited the Nuclear Energy Technology Company, which is responsible for low-level waste disposal and vitrification of low-level wastes. The low-level waste vitrification facility was toured. This facility uses the cold crucible method to vitrify the wastes.

### **CONCLUSIONS:**

Overall, the conference, tours, and the discussions with conference participants provided a good overview of the approaches being considered for nuclear waste disposal by many Asian countries. All of these programs are in relatively nascent stages. There is significant interest in Korea on container life prediction and the integration of various process level models into a system-level performance assessment calculation. The conference also showed a surprising absence of papers related to volcanic and other potentially disruptive processes and events on nuclear facilities, especially considering high level of seismic and volcanic activity throughout the Asian and Oceanic region represented by the conference. Finally, there was no significant European or North American presence at this conference.

### **PROBLEMS ENCOUNTERED:**

None.

### **PENDING ACTIONS:**

None.

### **RECOMMENDATIONS:**

The next AOCRP conference is slated to be held in the Peoples Republic of China. Because the AOCRP is of such broad scope (i.e., waste management was one of several topics

encompassed by the conference), future attendance needs to be evaluated in light of other available forums.

- The CNWRA and NRC staffs should examine the International Radiation Protection Association web site and evaluate which items should be considered for review and comment by NRC.
- Consideration should be given to broadening staff involvement in International Radiation Protection Association, as well as pertinent national and regional organizations.
- CNWRA staff should evaluate the work of Mikkelsen and colleagues at Riso National Laboratory with an eye toward using the data to calibrate CNWRA release models, evaluate U.S. Department of Energy and other licensee models, and collaborate in future investigations.
- CNWRA staff should evaluate the dynamic compartment model developed by Choi to assess its strengths and weaknesses, as well as potential areas of application.

**SIGNATURES:**

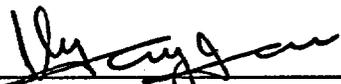
  
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