CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Nuclear Safety Research Conference 2003
Project Number 20.06002.01.081; AI Number 06002.01.081.318

DATE/PLACE: October 20–22, 2003
Washington, DC

AUTHOR: K. Chiang and J. Russell

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PERSONS PRESENT:

The conference was attended by approximately 350 researchers, regulators and utility representatives from the United States and 21other countries. Ken Chiang and John Russell from the Center for Nuclear Waste Analyses (CNWRA) participated in this conference.

BACKGROUND AND PURPOSE OF TRIP:

The Nuclear Safety Research Conference (NSRC) was sponsored by the Office of Nuclear Regulatory Research (RES) of the U.S. Nuclear Regulatory Commission (NRC). RES has sponsored this conference every year since 1973. This year, the NSRC was held on October 20–22, 2003 at the Marriott at Metro Center, Washington, DC. The purpose of staff attending this conference was to keep up-to-date on recent advances in topics of risk analysis methods and their application to risk-informed regulation, decommissioning, dry cask storage of spent nuclear fuel, degradation of fuels and cladding materials, advanced reactors, and the present status and future direction of materials degradation.

SUMMARY OF PERTINENT POINTS:

The conference agenda included seven technical sessions: (i) Risk-Informed Regulation/Realistic Conservatism, (ii) Decommissioning, (iii) Advanced Reactors, (iv) Behavior of Spent Fuel in Dry Cask, (v) High Burn-up Fuel Behavior During Reactor Accidents, (vi) Operating Experience Evaluation, and (vii) Materials Degradation—Present Status and Future Directions. Panels of experts discussed and invited questions on risk-informed regulations and realistic conservatism, knowledge management, and the present status and future direction of materials degradation. In addition, daily poster sessions were held to facilitate the presentation of additional technical materials. A summary of conference sessions and agenda is attached. A list of conference attendees, a book of conference abstracts and a CD on Fuels and Cladding Materials, and copies of presentations, are available from the author. All papers presented will be published in conference proceedings at a later date.

A number of presentations that are pertinent to CNWRA are summarized below.

K. A. Gruss (NRC) presented a paper, A Pilot Application of a Risk-Informed Approach for Certification of Dry Cask Storage of Spent Fuel. This paper discussed a pilot study that has

been designed to (i) test the effectiveness of risk-informed decision-making (RIDM) process, and supporting guidance documents, and (ii) improve standard review plan guidance for conducting confinement reviews for spent fuel storage in dry casks from any risk insights that are gained from the pilot study. The NRC Office of Nuclear Material Safety and Safeguards (NMSS) has utilized and is continuing to use risk information in various ways to achieve improvements in safety, efficiency, effectiveness, and reductions in unnecessary regulatory burden. In May 2003, NRC modified licensing review criteria related to the confinement capability of spent fuel storage casks with welded stainless steel canisters which is documented in Interim Staff Guidance No. 18 (ISG–18). The guidance removed the requirements for conducting a helium leakage test on the final closure lid of stainless steel all-welded spent fuel canisters. The proposed RIDM process and supporting guidance are being applied to assess the benefits of the new guidance contained in ISG–18. Preliminary results from the pilot study have shown that the ISG–18 not only maintains adequate levels of safety with respect to the operation of spent fuel storage casks but it relieves unnecessary regulatory burden and enhances the efficiency and effectiveness of the staff's confinement reviews. In the future, NMSS will place more emphasis on the use of a risk-informed approach to better focus its regulatory activities that most impact safety.

James A. Lake (Idaho National Engineering and Environmental laboratory) made a presentation on DOE Advanced Reactor Research. Nuclear energy has a strong role to play in satisfying our nation's future energy and environmental quality needs. A Generation IV implementation plan has been developed that focuses on two principal priorities: (i) Develop a Next Generation Nuclear Plant (NGNP), and (ii) Develop a fast reactor to reduce the volume and radiotoxicity, and to increase the manageability of spent nuclear fuel. Both priorities requires R&D in materials development. The NGNP is presently based on the very high temperature reactor (VHTR) design. Because the NGNP will be required to deliver 1,000 °C helium to the turbine or heat exchanger, R&D of high temperature materials is on the critical path. Today's high temperature alloys for reactor extend only to about 800 °C. Hence, further assessment of existing materials or selection of new materials is required. In the fast reactor area, the R&D needs are on demonstration of materials compatibility with operational conditions, and demonstration of materials operational in corrosive environments. DOE is expected to invest $200M in R&D over the next 10-year period on high temperature heat exchanger materials, vessel, turbine and internal materials.

John Flack (NRC) presented a paper, NRC's Advanced Reactor Research Program. NRC staff has assessed its technical, licensing, and inspection capabilities in order to identify the enhancements that will be needed to effectively and efficiently license and regulate advanced reactors. The scope of the infrastructure assessment and safety research plan is based on six advanced reactor designs: the Pebble Bed Modular Reactor; the Gas Turbine-Modular Helium Reactor; the Advanced Pressurized Water Reactor (AP-1000); the International Reactor Innovative and Secure; the General Electric Boiling Water Reactor; and the Advanced Canadian Deuterium-Natural Uranium Reactor (ACR-700). The "Generation IV" reactor design was not included in the assessment because of its early stage of development. The assessment focused on research that would be needed to support NRC's safety reviews for the four cornerstones of safety: accident prevention, accident mitigation, barrier protection, and offsite protection. Eight key research areas and its developmental activities having links to the cornerstones were identified: (i) accident analysis methods and assessments, human factors and instrumentation and control; (ii) reactor and plant system analysis; (iii) fuel analysis; (iv) materials analysis; (v) structural analysis; (vi) consequence analysis; (vii) nuclear materials

safety and waste safety; (viii) nuclear safeguards and security. Each of the technical areas were assessed in the context of the six advanced reactor designs and the challenges they presented from a regulatory perspective. The assessment also focused on the development of a new technology-neutral framework to be used for licencing advanced reactors and for making regulatory decisions based on risk-informed, performance-based principles.

Y. Yan (Argonne National Laboratory) presented a paper LOCA Results for Advanced-Alloy and High-Burnup Zircaloy Cladding. The Argonne test program is directed toward providing loss-of-coolant-accident (LOCA) relevant data for unirradiated advanced-alloy cladding, unirradiated Zircaloy-4 (Zry-4) cladding, and fueled high-burnup Zry-4 cladding. The purpose of the advanced alloy program is to determine the post-quench ductility of Zr-1Nb (M5) and Zr-1Sn-1Nb (ZIRLO) and Russian E110 (Zr-1Nb) alloys, as compared to the ductility of Zry-4 oxidized and quenched under the same time-temperature conditions. The current embrittlement criteria limit the peak cladding temperature to 1,204 °C and maximum oxidation (expressed as equivalent cladding reacted, ECR) to 17 percent to ensure core coolability during and following emergency core cooling system quench. Test results for Zry-4, ZIRLO, and M5 oxidized at 1,100 °C indicated that all three alloys exhibited about the same weight-gain kinetics, low hydrogen pick-up, and retention of ductility up to 20 percent ECR. The three alloys exhibited intact, black oxide layers, which are associated with protective oxide, parabolic oxidation kinetics and low hydrogen pickup. In contrast, E110 oxidized at 1,100 °C exhibited nodular breakaway oxidation—white and cracked in appearance, leading to oxygen-and-hydrogen embrittlement at <13 percent ECR.

J. Persensky (NRC) made a presentation on Davis-Besse Lessons Learned /Safety Culture. The root cause analysis performed by the Davis-Besse Nuclear Power Station on their reactor head degradation problem indicated that a root cause of the event was safety culture. The analysis indicated that the licensee staff and management exhibited less than adequate nuclear safety focus; weakness existed in safety culture, standards of performance; and decision making, and management did not effectively implement processes to detect and address plant problems as opportunities arose. The reactor head degradation was a significant condition adverse to quality that required correction and actions to preclude repetition. As part of the NRC evaluation of the licensee restart program, NRC inspectors are reviewing the effectiveness of the corrective action plan. The review consists of four parts: (i) evaluation of the licensee internal and external process, (ii) evaluation of the licensee long-term approach for monitoring safety and culture trends, (iii) evaluation of the licensee employee concerns program effectiveness, and (iv) evaluation of the licensee safety conscious work environment. For evaluation of the safety culture the inspectors are adapting guidance developed by the International Atomic Energy Agency and the International Nuclear Safety Advisory Group.

Roger W. Staehle (University of Minnesota) presented a paper on Predicting the Occurrence of Corrosion Failure in Nuclear Power Plant Components. Much of the work on corrosion in the nuclear industry has been reactive; and less has been predictive. Many failures that have occurred in the past were preceded by already available and credible evidence that such failure could occur. Important considerations for developing a framework for predicting future failures are: (i) many failures have taken long times to become obvious, (ii) most past failures have had precedents in laboratory experiments, (iii) failures occur frequently where there are combination of high residue stresses and local concentrations of impurities, (iv) pure environments in either the oxygenated or non-oxygenated conditions can also produce failures, (v) faulty processing of materials is rarely an underlying cause of failures. An example of possible predictable failure is

associated with the application of Alloy 690, which is used in tubing for nuclear steam generators. The current line-contact tube support design produces crevice corrosion conditions. Further the presence of lead and sulfur could produce stress corrosion cracking. While there is good experience in operating steam generators, there is ample evidence from laboratory studies that corrosion failure should be expected. Responsible actions could prevent or mitigate possibly significant damage.

Presentations from the session on Behavior of Spent Fuel in Dry Casks emphasized cladding behavior and the effects of potential hydride formation on mechanical properties of spent fuel, examining spent nuclear fuel stored in dry casks at the Idaho National Engineering and Environmental Laboratory for more than 15 years. These investigations provide valuable information to NRC for reviewing requests for renewals of dry cask storage licenses. Some of the original licenses for dry cask storage are approaching their 20-year expiration date. Researchers at Argonne National Laboratory, investigating Surry pressurized water reactor fuel rods stored for over 15 years in a Castor-V/21 cask, determined the rods were in excellent condition with no evidence of additional fission gas release, cladding creep, or oxidation. However, high burnup rods from the H. B. Robinson plant may be more vulnerable to damage due to greater exterior corrosion and radiation damage of the cladding and hydrogen uptake forming hydrides. One of the Robinson fuel rods ruptured during mechanical stressing. It was noted the NRC research program plans to investigate the dispersal of spent fuel from potential accidents involving dry cask transportation and storage.

R. Meck (NRC) and R. Anigstein (Sandy Cohen and Associates) discussed the status of assessments providing the technical basis for the proposed rulemaking on the release or clearance of equipment and materials from NRC-licensed nuclear facilities. The four volume report, NUREG-1640, evaluating potential doses from release of solid materials, should be completed by the end of 2003. The first two volumes have been published and the final two will be released in December 2003. Enhancements to the RESRAD family of pathway-dose modeling codes were discussed by S. Domoter (DOE) in the Decommissioning session. Recent enhancements include capabilities to calculate doses to the biosphere and to offsite human receptors.

SUMMARY OF ACTIVITIES:

None.

IMPRESSIONS/CONCLUSIONS:

The NSRC was well attended by U.S. government, national laboratories, academics, and nuclear industries, as well as representatives from more than 20 countries. The countries of international participants include France, Germany, Canada, Spain, Korea, Japan, Russian, Sweden, United Kingdom, Finland, Mexico, among others. This conference was focused on risk-informed regulation, safety and regulatory issues, and materials degradation. Participants at the conference were given the opportunity to interact with NRC staff and colleagues and obtain insights and results from research programs performed in support of the NRC's mission.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

The conference is valuable to staff in getting first hand information on nuclear regulatory issues directly from the NRC chairman, NRC commissioners, and representatives from NRC, DOE, National Laboratories, and research groups from United States and internationally. Attendance at future conferences by CNWRA staff is recommended.

SIGNATURES:

K.T. Chiang — 11-5-03

Ken Chiang
Senior Research Scientist — Date

Budhi Sagar for JR — 11/05/03

John Russell, Director
Washington Technical Support Office — Date

CONCURRENCE:

11/5/03

Vijay Jain, Manager
Corrosion Science & Process Engineering, Element — Date

11/05/03

Budhi Sagar
Technical Director — Date

Attachment

KC:jg

Organized by:
Office of Nuclear Regulatory Research
United States Nuclear Regulatory Commission
Washington, DC 20555

Nuclear Safety Research Conference 2003

Session Schedule & Room Locations

MONDAY	8:30 am	Plenary Session: NRC Chairman's Keynote Speech	Grand Ballrooms A, B, C
	10:00 am	Panel Discussion	Grand Ballrooms A, B, C
	12:00 noon	Lunch – On Your Own	See Hotel for Restaurant Specials
	1:30 pm	Session 1 (Plenary)	Grand Ballrooms A, B, C
TUESDAY	8:30 am	Plenary Session: NRC Commissioner, Speaker	Grand Ballrooms A, B, C
	9:30 am	Session 2	Salon A
		Session 3	Salon B
	11:00 am	Session 4	Salon C
	12:30 pm	Lunch – On Your Own	See Hotel for Restaurant Specials
	2:00 pm	Session 5	Salon C
		Session 6	Salon A
WEDNESDAY	8:30 am	Plenary Session: NRC Commissioner, Speaker	Grand Ballrooms A, B, C
	9:30 am	Panel Discussion	Grand Ballrooms A, B, C
	10:45 am	Panel Discussion	Grand Ballrooms A, B, C
	12:30 pm	Lunch – On Your Own	See Hotel for Restaurant Specials
	2:00 pm	Session 7	Grand Ballrooms A, B, C
	4:20 pm	Closing Remarks and Audience Feedback	Grand Ballrooms A, B, C

Susan Monteleone, BNL, Conference Coordinator

Monday, October 20, 2003

8:30 **Plenary Session (Grand Ballroom)**

Opening Remarks and Welcome

Ashok C. Thadani, Director, Office of Nuclear Regulatory Research

8:45 **Keynote Speaker:**

Nils J. Diaz, NRC Chairman

9:45 Break

10:00 **Panel Discussion:** ***Risk-Informed Regulation/Realistic Conservatism***

Panel Members: Mario Bonaca (ACRS)
Lothar Hahn (GRS)
Mike Knapik (Inside NRC)
Tony Pietrangelo (NEI)
Loren Plisco (NRC)

Scott Newberry (NRC), Panel Moderator

12:00 Lunch

Risk-Informed Regulation/Realistic Conservatism

Chaired by: H. Hamzehee, M. Reinhart (NRC)

Objective: To discuss recent advances in risk analysis methods and their application to risk-informed regulation.

1:30 Addressing the Issue of PRA Quality
M. Drouin, G. Parry (NRC)

2:00 Experience with PRA in the Generic Issues Program
H. VanderMolen (NRC)

2:30 A Pilot Application of a Risk-Informed Approach for Certification of Dry Cask Storage of Spent Fuel
K. Gruss, M. Waters, C. Lui (NRC)

3:00 Break

3:15 Fire Risk Research Program: Advances Supporting Risk-Informed Regulation, J. Hyslop (NRC)

3:45 10CRF50.46, J. Lane, A. Buslik, H. Hamzehee (NRC)

4:15 LOCA Frequencies and Break Size Redefinition using Expert Elicitation, R. Tregoning (NRC)

Poster Sessions

A Risk-Informed Re-Evaluation of the Technical Basis for the Pressurized Thermal Shock Rule (10CFR50.61) and Associated Screening Criteria, M. Kirk, et al. (NRC)

Full-Scale Nuclear Power Plant Compartment Fire Experiments for Fire Model Validation, A. Hamins, et al. (NIST)

The Effects of Aliovalent Elements on Nodular Oxidation of Zr-Base Alloys, H. Chung (ANL)

LOCA Testing at Halden, E. Kolstad, V. Lestinen, W. Wiesenack (OECD Halden Reactor Project)

Scaling Methods for RIA Data, R. Meyer (NRC)

Recent Results from LOCA Study at JAERI, F. Nagase, T. Fuketa (JAERI)

Key Input Variables for RIA Simulations: A Study Based on FRAPCON and SCANAIR Codes, F. Barrio, L. Herranz (CIEMAT-Spain)

TRACE, C. Murray, J. Staudenmeir (NRC)

Debris Impact on PWR Sump Performance
T. Y. Chang (NRC)

Package Performance Study, A. Murphy (NRC)

Emerging Technology, R. Shaffer, C. Antonescu, S. Arndt, and T. Govan (NRC)

Digital Feedwater System Reliability Assessment
J. Calvert (NRC)

Tuesday, October 21, 2003

8:30 **Plenary Session (Grand Ballroom)**

Guest Speaker: Jeffrey S. Merrifield, Commissioner, NRC

9:15 Break

2 Decommissioning

Chaired by: W. Ott (NRC)

Objective: To discuss RES work underway that supports license decision-making in decommissioning by using more realistic tools, and rule-making on 1) controlling the disposition of solid materials, and 2) reactor entombment.

9:30 NUREG-1640: Radiological Assessments for Clearance of Equipment and Materials from Nuclear Facilities
R. Meck (NRC), R. Anigstein (SC&A)

9:50 Survey Guidance
C. Gogolak (EML-DHS)

10:10 Enhancements to the RESRAD Family of Dose Modeling Codes, S. Domoter (DOE)

10:30 Evaluation of Entombment as a Decommissioning Option for Nuclear Power Reactors, K. Snyder (NIST), J. Philip (NRC)

3 Advanced Reactors

Chaired by: S. Rubin, J. Lyons (NRC)

Objective: To present the latest research on advanced reactors, focusing on new and evolving safety or regulatory issues, and the infrastructure needed to form a sound technical basis for regulatory decisions.

9:30 NRC's Advanced Reactor Research Program, J. Flack (NRC)

10:00 Advanced Reactor Research: DOE Sponsored
J. Lake, R. Schultz (INEEL)

10:30 Analytical Codes and Data Needs for Advanced Reactors
S. Bajorek (NRC)

11:00 Regulatory Process/Structure for Future Nuclear Power Plant Licensing, M. Drouin, T. King (NRC), J. Lehner, W. Pratt, V. Mubayi (BNL)

11:30 Generation IV Concepts and Technology Challenges
J. Remer (DOE)

4 Behavior of Spent Fuel in Dry Casks

Chaired by: R. Meyer, C. Interrante (NRC)

Objective: To describe recent research results on fuel behavior under conditions expected in dry casks.

11:00 Introductory Remarks on Spent Fuel Research Needs
C. Interrante (NRC)

11:15 Cladding Behavior During Dry Cask Handling and Storage
H. Tsai, M. Billone (ANL)

11:45 Mechanical Properties of Irradiated Zircaloy-4 for Dry Cask Storage Conditions and Accidents
R. Daum, S. Majumdar, M. Billone (ANL)

12:30 Lunch

5 High Burnup Fuel Behavior During Reactor Accidents

Chaired by: R. Meyer (NRC), R. Yang (EPRI)

Objective: To describe recent research results on high-burnup fuel and on cladding alloys that have been introduced to achieve high burnups.

2:00 LOCA Results for Advanced-Alloy and High-Burnup Zircaloy Cladding, Y. Yan, T. Burseva, M. Billone (ANL)

2:30 LOCA Behavior of E110 Alloy, L. Yegorova, K. Lioutov (NSI Kurchatov Institute), V. Smirnov, A. Goryachev, V. Chesanov (RIAR)

3:00 Recent Data on M5™ Alloy Under LOCA Conditions
J. Mardon (Framatome), N. Waeckel (EDF-SEPTEN)

3:30 Break

3:45 Effects of Pellet Expansion and Cladding Hydrides on PCMI Failure of High Burnup LWR Fuel During Reactivity Transients, T. Fuketa, et al. (JAERI)

4:15 CABRI CIP0-1 Preliminary Test Results, J-C Melis, et al. (IRSN)

6 Operating Experience Evaluation

Chaired by: J. Ibarra (NRC)

Objective: To describe several studies wherein RES had a critical role in assessing operating experience and disseminating those findings to staff and the industry. Also, to present RES's major on-going involvement in reassessing NRC's current operating experience programs prompted by the head degradation incident at the Davis Besse plant.

2:00 Electrical Grid Study, W. Raughley (NRC)

2:25 Overview of Research Findings on the Mitigating Systems Performance Index (MSPI), D. Dube (NRC)

2:50 Boron Dilution Tests/PKL, R. Zipper (GRS)

3:15 Break

3:30 Davis Besse Lessons Learned / Safety Culture
J. Persensky (NRC)

3:55 Operating Experience Task Force, J. Ibarra (NRC)

WEDNESDAY, OCTOBER 22, 2003

8:30 **Plenary Session (Grand Ballroom)**
Guest Speaker: Edward McGaffigan, Jr., Commissioner, NRC

9:15 Break

9:30 **Panel Discussion: *Knowledge Management***
Panel Members: Earl Carnes (DOE)
Jeanne Holm (NASA)
Jack Haugh (EPRI)

Ramin Assa (NRC), Panel Moderator

10:30 Break

10:45 **Panel Discussion: *Materials Degradation - Present Status and Future Directions***

Panel Members: Paul Gunter (NIRS)
Alex Marion (NEI)
Brian Sheron (NRC)
Jack Strosnider (NRC)
Christer Viktorsson (SKI)

Michael Mayfield (NRC), Panel Moderator

12:30 Lunch

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7 MATERIALS DEGRADATION - PRESENT STATUS AND FUTURE DIRECTIONS

Chaired by W. Cullen (NRC)

Objective: To describe the results of characterizing degradation mechanisms in reactor coolant pressure boundary materials, methodologies for their mitigation/repair, and actions planned for evaluating and managing such degradation.

2:00 NDE for Reactor Pressure Vessel Head Replacements
S. Doctor (PNNL)

2:25 Predicting the Occurrence of Corrosion Failures in Nuclear Power Plant Components
R. Staehle (U. Minnesota), J. Gorman (Dominion Engineering)

2:50 Anticipating Materials Problems: Field Experience and Laboratory Studies, W. Shack, O. Chopra (ANL)

3:15 Break

3:30 Strategic Planning for RPV Head Nozzle PWSCC
S. Hunt (Dominion Engineering)

3:55 Acknowledging the Past to Prepare for the Future
D. Steininger (EPRI)

4:20 **Closing Remarks and Audience Feedback**