Foreign Travel: Quick Look and Final Report

Dates of Travel: October 24-31, 2009

Location: Cordoba, Spain

Organization: Office of Nuclear Material Safety and Safeguards (NMSS) and Office of Research (RES)

Purpose: To participate in the annual meeting of the Nuclear Energy Agency's (NEA) Expert Group on Burnup Credit (EG BUC) on October 26, as well as the International Atomic Energy Agency (IAEA) Workshop on Advances in Applications of Burnup Credit for Spent Fuel Storage, Transport, Reprocessing, and Disposition, from October 27 to 30.

Desired Outcome: NRC and its contractors intended to present several papers detailing recent work in the area of spent nuclear fuel burnup credit for pool storage, dry cask storage and transportation, and disposal. Additionally, NRC and its contractors intended to discuss upcoming efforts to expand the technical basis for burnup credit in the U.S., in order to get technical feedback from the international criticality safety community.

Results Achieved: NRC staff and Oak Ridge National Laboratory (ORNL) contractors participated in the EG BUC by providing an update on U.S. domestic burnup credit activities, as well as on participation in the various international burnup credit studies. NRC staff and ORNL contractors presented a total of eight technical papers in three sessions of the IAEA Burnup Credit Workshop. Additionally, staff and contractors chaired several of the sessions, and participated in three expert panel discussions on the final day of the workshop. Participation in these meetings provided ample opportunity for staff and contractors to gain feedback from the international criticality safety community on current U.S. burnup credit criticality practices, as well as on proposed near-term changes to NRC burnup credit recommendations.

Summary of Trip: During the week of October 26, 2009, Andrew Barto of NMSS/SFST, Sheena Whaley of NMSS/HLWRS, Mourad Aissa of RES/DSA, John Wagner of ORNL, and Ian Gauld of ORNL, travelled to Cordoba, Spain to participate in a meeting of the NEA EG BUC on October 26, as well as the IAEA Workshop on Advances in Applications of Burnup Credit for Spent Fuel Storage, Transport, Reprocessing, and Disposition, from October 27 to 30.

NEA EG BUC (October 26, 2009)

This expert group is made up of regulators, criticality safety practitioners, and research scientists who are involved in, or are investigating the use of, burnup credit in the various member countries. This group meets annually to discuss the status of the use of burnup credit in each member country, as well as to discuss the results of computational benchmark studies that have been performed by each country for compilation into a series of burnup credit reports published by NEA. Representatives from 13 countries participated in this expert group meeting.

The following are highlights from the meeting:

- All member countries represented at the meeting provided a summary of burnup credit activities. It was noted that most of the burnup credit used in other countries is related to reprocessing, where the need for it is greatest. Although some countries have moved forward with limited burnup credit in spent fuel pool, transportation package, and proposed disposal designs, no country appeared to rely on it to the level that the U.S. does in pool storage and transportation.

- John Wagner provided an update on the computational benchmark activities related to long term disposal reactivity, known as the Phase VII benchmark exercise. This exercise involves calculating spent fuel disposal package reactivity out to various decay times ranging from 1 year up to 1,000,000 years. The member countries that performed the benchmark exercise have submitted their results to ORNL, and a draft of the summary report is expected later this year, with the final report expected in April of next year.
- The next NEA EG BUC meeting is scheduled for September, 2010, in conjunction with the meeting of the NEA Working Party on Nuclear Criticality Safety.

<u>IAEA Burnup Credit Workshop (October 27-30, 2009)</u>
The IAEA International Workshop on Advances in Applications of Burnup Credit for Spent Fuel Storage, Transport, Reprocessing, and Disposition has been held once every several years since the early 1990s. The objectives of the workshop were to identify the benefits that have accrued from recent improvements in burnup credit analysis methodologies; to discuss and analyze the implications of applying improved burnup credit methodologies, focusing on both the safety-related and operational aspects; and to foster the exchange of international experience in licensing and implementation of burnup credit applications.

The following are highlights from the workshop:
- In Session I of the Workshop, "International and National Reports," John Wagner provided a review of technical studies performed by ORNL in the past decade, in support of burnup credit regulatory guidance. These studies have included investigations into the effects of various fuel depletion parameters on reactivity of spent fuel, examination of newly available isotopic depletion and criticality code validation data, evaluation of the effects of spent fuel misloads on high capacity spent fuel transportation package reactivity, and compilation of information related to spent fuel burnup determination and confirmation. This presentation was intended to make international participants who have only been recently involved in burnup credit aware of studies that have been published in various NUREG/CR documents, in order that work is not duplicated internationally.
- In Session II.A of the Workshop, "Calculation Methods – Codes and Methods," co-chaired by John Wagner, Ian Gauld presented recent enhancements to the *STARBUCS* Burnup Credit Criticality Safety Analysis Sequence in the Standardized Computer Analyses for Licensing Evaluation (SCALE) code package, developed under the NMSS/SFST SCALE contract with ORNL. This code is unique in its ability to perform both the isotopic depletion and criticality calculations for a burnup credit criticality analysis, in a single code sequence.
- In Session II.D of the Workshop, "Calculation Methods - Verification and Validation," co-chaired by Ian Gauld, Andrew Barto presented the regulatory perspective on computer code validation for burnup credit criticality analyses in spent fuel transportation. This presentation outlined the technical basis for NRC's current guidance for actinide-only burnup credit in transportation, as well as considerations for a proposed expansion of this technical basis to include fission product credit. Additionally during this Session, Ian Gauld presented the validation experience of the SCALE code system isotopic depletion sequence using newly available radiochemical assay data for higher burnup fuel and fission products.
- In Session III of the Workshop, "Applications and Implementation," co-chaired by Andrew Barto, Mourad Aissa presented a discussion of the generation and accuracy of individual fuel assembly burnup reactor records. Additionally in this Session, Andrew Barto presented the regulatory perspective on confirmatory burnup measurements for fuel to be loaded in burnup credit transportation packages. Both of these papers related to the recommended burnup verification measurement for burnup credit package loading, and current proposals in the U.S. to identify alternatives to this measurement. Two additional papers were presented by John Wagner in this Session, one summarizing the results of the NEA EG BUC Phase VII

Benchmark discussed at the EG BUC meeting, and another outlining the burnup credit approach for the proposed U.S. repository at Yucca Mountain.

- NRC staff and ORNL contractors participated in three panel discussions on Friday, October 30, during which Workshop participants asked questions of the Panel members related to the each Panel topic. John Wagner participated in Panel I on code developments and nuclear data, Ian Gauld participated in Panel II on sensitivity/uncertainty analysis, verification and validation, and Andrew Barto participated in Panel III on applications and implementation.
- A general conclusion by the NRC staff and ORNL contractors that attended the Workshop was that, although some countries have moved forward with limited burnup credit in spent fuel pool, transportation package, and proposed disposal designs, no country appeared to rely on it to the level that the U.S. does in pool storage and transportation.
- A time and place for the next Burnup Credit Workshop was not discussed. These meetings have occurred in the past at four year intervals. The consensus of the Workshop attendees was that burnup credit would remain as a major topic of the International Conference on Nuclear Criticality (ICNC), to be held in Edinburgh, Scotland in September, 2011.

Next Steps:

- NRC will continue to participate in annual meetings of the NEA EG BUC, as well as any future Burnup Credit Workshops.
- NRC will use these meetings to maintain awareness of international activities in the area of burnup credit criticality analysis, as well as to gain feedback from the international criticality safety community on current U.S. burnup credit criticality practices, as well as on proposed changes to NRC burnup credit guidance recommendations.

Were policy issues or other items of Commission interest raised? If yes, how has or will the Commission be informed? No

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Are policy issues or other items of Commission interest expected to be raised? If yes, how has or will the Commission be informed? No

Attachment 1: Meeting Agenda

BUC WORKSHOP AGENDA

Tuesday October 27th

08:30-09:00

OPENING OF THE WORKSHOP
Welcome address
José M. Conde (CSN)
Description of the Technical Agenda
Jens-Christian Neuber (AREVA)
General Announcements and Practicalities
Consuelo Alejano (CSN)

SESSION I: INTERNATIONAL AND NATIONAL REPORTS **09:00-15:30**
Co-Chairs: J.-C. Neuber (AREVA), J. M. Conde (CSN)

1.1	"BUC activities performed by IAEA" *Zvonko Lovasic (IAEA)*	09:00-09:30
1.2	"Lessons Learned from International Investigations of Burnup Credit Criticality" *M. C. Brady-Raap (PNNL), J. Gulliford (NNL), L. Markova (NRI), H. Okuno (JAEA), G. O'Connor (UK DfT), P. H. Liem (NAIS)*	09:30-10:00
1.3	"Activities of the OECD/NEA Expert Group on Assay Data for Spent Nuclear Fuel" *Ian C. Gauld (ORNL), Y. Rugama (NEA)*	10:00-10:30

Coffee break 10:30-11:00

1.4	"Burnup Credit Development and Implementation in the Slovak Republic" *Juraj Vaclav (NRA SR)*	11:00-11:30
1.5	"Applying Burn-up Credit Technology for Spent Fuel Storage in China" *Guoshun You, Qingfu Zhu, Chuanwen Hu (CIAE)*	11:30-12:00
1.6	"National program for BUC application in India" *A. K. Pandey,(NPCIL)*	12:00-12:30
1.7	"Research Activities of JAEA Considering the Future Needs of Japan in Burnup Credit Implementation" *H. Okuno, K. Tonoike, K. Suyama, K. Ohkubo, G. Uchiyama (JAEA)*	12:30-13:00

Lunch break 13:00-14:30

1.8	"Review of Technical Studies in the United States in Support of Burnup Credit Regulatory Guidance" *J. C. Wagner, C. V. Parks, D. E. Mueller, I. C. Gauld (ORNL)*	14:30-15:00
1.9	"Latest Studies Related to the Use of Burnup Credit in France" *L. Jutier, I. Ortíz de Echevarría and S. Evo (IRSN), E. Guillou and J. Jaunet (AREVA), A. Bonne (EDF)*	15:00-15:30

SESSION II: CALCULATION METHODS
II.A Codes and methods **15:30-17:45**
Co-Chairs: S. Evo (IRSN), John C. Wagner (ORNL)

	Chair overview of the status and the main challenges in burnup credit depletion calculation	15:30-15:40
2.1	"Enhancements to the Burnup Credit Criticality Safety Analysis Sequence in SCALE" *G. Radulescu, Ian C. Gauld (ORNL)*	15:40-16:05

Coffee break 16:05-16:30

2.2	"Assessment of the MCNP+ACAB Code System for Burnup Credit Analysis" *N. García-Herranz, O. Cabellos, J. Sanz (UPM)*	16:30-16:55
2.3	"Convergence issues in Best-estimate Monte Carlo Depletion Calculations" *Y. Richet, W. Haeck, B. Cochet and J. Miss (IRSN), O. Jacquet (Consultant)*	16:55-17:20
2.4	"Peak Reactivity Characterization and Isotopic Inventory Calculations for BWR Criticality Applications" *C. Casado, J. Sabater, J. F. Serrano (ENUSA)*	17:20-17:45

Wednesday October 28th

II.B Nuclear and assay data **08:30-10:15**
Co-Chairs: A. Santamarina (CEA), R. D. McKnight (ANL)

	Chair overview of the main improvements in nuclear data with respect to burnup credit nuclides and on the availability of assay data	08:30-08:45
2.5	"Correction Factors Derived from French Experiments with the Recent JEFF3.1.1 Library for PWR-UOx BUC Applications" *C. Riffard, A. Santamarina, and L. San Felice (CEA), J.-F. Thro (AREVA NC)*	08:45-09:15
2.6	"Study of Burnup Reactivity and Isotopic Inventory in REBUS Program" *T. Yamamoto and Y. Ando (JAEA), K. Sakurada and Y. Hayashi (Toshiba)*	09:15-09:45
2.7	"PWR and BWR Fuel Assay Data Measurements" *C. Alejano and J.M. Conde (CSN), M. Quecedo and M. Lloret (ENUSA), P. Zuloaga and F. J. Fernández (ENRESA), J. A. Gago (ENDESA)*	09:45-10:15

Coffee break 10:15-10:45

II.C Sensitivity/Uncertainty analyses **10:45-13:00**
Co-Chairs: J.-C. Neuber (AREVA), T. Ivanova (IRSN)

	Chair overview of the objectives, key concepts, and methods	10:45-11:00
2.8	"Sensitivity/uncertainty Analysis applied to the Phase VII Benchmark" *O. Cabellos, B. Cabellos and N. García-Herranz (UPM), J. Sanz (UNED), P. Ortego (SEA)*	11:00-11:30
2.9	"Use of French Fission Product Experiments for Burnup Credit Validation" *T.Ivanova, N. Leclaire, E. Létang (IRSN), J.-F. Thro (AREVA NC)*	11:30-12:00
2.10	"General hierarchical Bayesian procedure for calculating the bias and the a posteriori uncertainty of neutron multiplication factors" *J.-C. Neuber, A. Hoefer (AREVA)*	12:00-12:30
2.11	"Usage of TSUNAMI in a Hierarchical Bayesian Procedure for Calculating the Bias and the a posteriori Uncertainty of keff" *J.-C. Neuber, A. Hoefer (AREVA)*	12:30-13:00

Lunch break 13:00-14:30

II.D Verification and validation **14:30-17:45**
Co-Chairs: M. Brady-Raap (PNNL), Ian C. Gauld (ORNL)

	Chair overview of the available data and methods	14:30-14:45
2.12	"Determination of a Depletion Uncertainty from Fuel Management Experience" *D. B. Lancaster (NuclearConsultants.com), C. T. Rombough (CTR)*	14:45-15:15
2.13	"Sufficiency of Available MOX Experiments for Criticality calculation validation of VVER Burnup Credit Application" *G. Hordosy (KFKI), S. Patai Szabo (ANANDOR)*	15:15-15:45
2.14	"Evaluation of Fission Product Critical Experiments and Associated Biases for Burnup Credit	15:45-16:15

	Validation" *D. E. Mueller, B. T. Rearden, D. A. Reed (ORNL)*	

Coffee break 16:15-16:45

2.15	"Regulatory Perspective on Computer Code Validation for Burnup Credit Criticality Analyses for Spent Nuclear Fuel Transportation Packages" *M. Rahimi, Z. Li, M. Call (USNRC)*	16:45-17:15
2.16	"SCALE Validation Experience using an Expanded Isotopic Assay Database for Spent Nuclear Fuel" *I. C. Gauld, G. Radulescu, G. Ilas (ORNL)*	17:15-17:45

Thursday October 29th

SESSION III: APPLICATIONS AND IMPLEMENTATION **08:30-17:30**
Co-Chairs: J. Gulliford (NNL), A. Barto (USNRC)

	Chair overview of reactor operations impacting the spent fuel reactivity and the burnup distribution	08:30-08:45
3.1	"Regulatory Perspective on Confirmatory Burnup Measurements for Burnup Credit in Spent Nuclear Fuel Transportation Packages " *A. Barto, N. Jordan (USNRC)*	08:45-09:15
3.2	"Fuel Burnup Plant Records: Generation and Accuracy" *M. Aissa (USNRC)*	09:15-09:45
3.3	"Recommended Bounding Axial Burnup Profiles In BUC Applications From Actual Burnup Measurement Of French PWR Assemblies" *C. Riffard and A. Santamarina (CEA), J.-F. Thro (AREVA-NC), F. Lavaud (EdF)*	09:45-10:15

Coffee break 10:15-10:45

3.4	"Inventory Prediction and BUC Calculations Related to MEU/LEU IRT Fuels of LVR-15 Research" *L. Markova, F. Havluj, M. Marek (NRI)*	10:45-11:15
3.5	"Fuel Depletion Calculation in MTR-LEU NUR Reactor" *Z. Fodil (COMENA)*	11:15-11:45
3.6	"Burnup Credit in the Swedish Interim Storage Facility (CLAB)" *L. Agrenius (Agrenius Ingenjörsbyra AB)*	12:15-12:45

Lunch break 12:45-14:30

3.7	"Lessons Learnt from OECD/NEA Phase II-C through Phase II-E Benchmarks" *J.-C. Neuber (AREVA)*	14:30-15:00
3.8	"Review of results for the OECD/NEA Phase VII Benchmark: Study of the Spent Fuel Compositions for Long Term disposal" *G. Radulescu, J. Wagner (ORNL)*	15:00-15:30
3.9	"Burnup Credit Approach for the Proposed United States Repository at Yucca Mountain" *J. M. Scaglione, J. C. Wagner (ORNL)*	15:30-16:00

Coffee break 16:00-16:30

3.10	"Regulatory Issues for Final Disposal" *J.-C. Neuber (AREVA)*	16:30-17:00
3.11	"Burnup Credit in the Canister for Final Disposal of Spent Nuclear Fuel" *L. Agrenius (Agrenius Ingenjörsbyra AB)*	17:00-17:30

Friday October 30th

PANEL DISCUSSIONS **09:00-12:30**

Panel I: Code developments and nuclear data **09:00-10:00**
Chair: A. Santamarina (CEA)
Participants: S. Evo (IRSN)
J. C. Wagner (ORNL)
R. D. McKnight (ANL)
Y. Rugama (NEA)

Panel II: Sensitivity/uncertainty analysis, verification and validation **10:00-11:00**
Chair: J.-C. Neuber (AREVA)
Participants: T. Ivanova (IRSN)
D. Mueller (ORNL)
O. Cabellos (UPM)
Ian C. Gauld (ORNL)
A. Vasiliev (PSI)

Coffee break 11:00-11:30

Panel III: Applications and implementation **11:30-12:30**
Chair: J. Gulliford (NNL)
Participants: M. Brady-Raap (PNNL)
A. Barto (NRC)
R. Kilger (GRS)
J. Vaclav (NRA SR)
J. F. Serrano (ENUSA)

CLOSING SESSION **12:30-13:00**