

**LLNL-MI-645309**  
**CSAM 13-1660**

**Trip Report**

Working Party on Nuclear Criticality Safety Expert Groups and Governance Meetings  
at OECD NEA Headquarters, October 7-11, 2013



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**Auspices**

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## Introduction

The Working Party on Nuclear Criticality Safety (WPNCS) convened expert group and governance meetings during the week of October 7-11, 2013 at the Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) Headquarters at 12 Boulevard des Iles, Issy-les-Moulineaux, Paris, France.

The official host for these meetings was Jim Gulliford (OECD/NEA Nuclear Science Committee) with support from Franco Michel-Sendis.

John Scorby and Dave Heinrichs attended these meetings as official delegates under the auspices of the USDOE Nuclear Criticality Safety Program as described in Appendix C, Fiscal Year 2014 Projected Foreign Travel, of the “United States Department of Energy Nuclear Criticality Safety Program Five-Year Execution Plan for the Mission and Vision, FY2014 through FY2018.”

Due to US Government Budget issues, the only other delegates from the United States were Mikey Brady-Raap (PNNL), Cecil Parks (ORNL), Sedat Goluoglu (U. of Florida) and a student (U. of Florida). This represented an all time low in US participation. In contrast, there were several participants from 15 other countries; namely, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Russia, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

## Timetable

Date	Time	Group	Subject
Monday, October 7	9:30 - 18:00	EGCEA	Criticality Excursions
Tuesday, October 8	9:30 - 18:00	EGADSNF	Spent Nuclear Fuel Isotopic Data
Wednesday, October 9	9:30 - 13:15	EGADSNF	Spent Nuclear Fuel Isotopic Data
Thursday, October 10	9:30 - 18:00	EGBUC	Burn-up Credit
Friday, October 11	9:00 - 18:00	WPNCS	Governance

A summary of each expert group meeting is provided in the following sections followed by the meeting agendas.

## Criticality Excursions

The focus of the EGCEA has been to develop benchmark specifications<sup>1</sup> derived from SILENE and TRACY and for the participants to provide simulation results for purposes of inter-code comparisons. The chair of this meeting was Yoshinori Miyoshi (JAEA) and the agenda is provided in the Appendix. The Summary Record of the previous EGCEA meeting was also distributed.

<sup>1</sup> Y. Miyoshi et al., *Inter-code Comparison Exercise for Criticality Excursion Analysis, Benchmark Phase I: Pulse Mode Experiments with Uranyl Nitrate Solution in the TRACY and SILENE Facilities*, NEA No. 6285, OECD 2009. [http://www.oecd-nea.org/science/reports/2009/6285\\_CriticalityComparison.pdf](http://www.oecd-nea.org/science/reports/2009/6285_CriticalityComparison.pdf)

Participants in this expert group are using the codes AGNES, CRITEX, FETCH, INCTAC and TRACE. Of these, only FETCH is a true multiphysics code consisting of the open source FLUIDITY<sup>2</sup> computational fluid dynamics (CFD) code coupled to the EVENT<sup>3</sup> neutron transport code. These codes were developed at Imperial College in the United Kingdom. The other four codes are of limited utility and solve simplified coupled first-order ordinary differential equations (similar to MRKJ).

LLNL multiphysics methods have recently implemented time-dependent emission of delayed neutrons. However, LLNL is not yet ready to attempt solving the EGCEA benchmarks as our methods lack a bubble formation model. Such models used in FETCH and the other codes are simply proportional to energy deposition above a threshold. Therefore in principle, implementing such a model should be straightforward.

In sidebar discussions with the FETCH participant, Paul Smith (SERCO) agreed that it should be possible to utilize FETCH to calculate low GODIVA-I yields dominated by thermal expansion. As a follow-up action, LLNL plans to provide Smith with the relevant data to perform these simulations. If successful, LLNL will attempt to utilize FETCH and LLNL methods to similarly calculate Flattop sub-prompt critical excursions, which are dominated by the effect of delayed neutrons on long reactor periods. If these calculations are successful, then LLNL will seek authorization to contribute simulation results from our multiphysics methods as well as encourage AWE and LANL to provide similar results using their methods in developing simple EGCEA criticality excursion benchmarks for Godiva-1 and Flattop.

As a follow-up to an idea proposed in the previous EGCEA meeting, preliminary benchmark specifications were proposed for a simple rectangular (open) tank containing low concentration plutonium nitrate solution. There is no experimental basis for this system and the purpose of this analytical benchmark is to computationally explore the effect of a system with increasingly positive temperature coefficient.

Lastly, the participants from Japan described their multi-year effort to evaluate the criticality safety of Fukushima fuel debris. This effort includes new critical experiments.

### **Assay (Isotopic) Data for Spent Nuclear Fuel**

The goal of the EGADSNF has been to develop the Spent Fuel Isotopic Composition Database (SFCOMPO) consisting of isotopic benchmark data including actinides and fission products measured from irradiated samples together with the fuel design and reactor operating history enabling detailed depletion calculations to predict the isotopic contents of the fuel in the vicinity of the samples. This method is described in a recent

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<sup>2</sup> <http://www3.imperial.ac.uk/earthscienceandengineering/research/amcg/fluidity>

<sup>3</sup> <http://www3.imperial.ac.uk/earthscienceandengineering/research/amcg/event>

OECD report<sup>4</sup>. These isotopic benchmarks enable validation of methods for calculating spent fuel isotopics for burn-up credit in criticality safety evaluations for the storage and transport of spent nuclear fuel.

The SFCOMPO database as publicly available on-line contains entries for 107 samples taken from 14 reactors as summarized below.

Reactor	Country	Type	Assembly	Fuel Type	Number of Samples (Number of UO <sub>2</sub> -Gd <sub>2</sub> O <sub>3</sub> )
Obrigheim	Germany	PWR	14 * 14	UO <sub>2</sub>	23
Gundremmingen	Germany	BWR	6 * 6	UO <sub>2</sub>	12
Trino Vercellese	Italy	PWR	15 * 15	UO <sub>2</sub>	39
JPDR	Japan	BWR	6 * 6	UO <sub>2</sub>	30
Tsuruga-1	Japan	BWR	7 * 7	UO <sub>2</sub>	10
Fukushima-Daiichi-3	Japan	BWR	8 * 8	UO <sub>2</sub> ,UO <sub>2</sub> -Gd <sub>2</sub> O <sub>3</sub>	36 (10)
Fukushima-Daini-2	Japan	BWR	8 * 8	UO <sub>2</sub> ,UO <sub>2</sub> -Gd <sub>2</sub> O <sub>3</sub>	18 (10)
Mihama-3	Japan	PWR	15 * 15	UO <sub>2</sub>	9
Genkai-1	Japan	PWR	14 * 14	UO <sub>2</sub>	2
Takahama-3	Japan	PWR	17*17	UO <sub>2</sub> ,UO <sub>2</sub> -Gd <sub>2</sub> O <sub>3</sub>	16(5)
Cooper	USA	BWR	7 * 7	UO <sub>2</sub>	6
Monticello	USA	BWR	8*8	UO <sub>2</sub> ,UO <sub>2</sub> -Gd <sub>2</sub> O <sub>3</sub>	30(5)
Calvert Cliffs No.1	USA	PWR	14 * 14	UO <sub>2</sub>	9
H.B.Robinson Unit2	USA	PWR	15 * 15	UO <sub>2</sub>	6

The database is being expanded to include additional sample data from many more reactors including additional PWRs and AGRs, Magnox reactors and VVERs. A Master of Science candidate at the University of Florida is attempting to evolve the PWR portion of the SFCOMPO database into a standard handbook (similar to the ICSBEP handbook). This effort is just getting started.

Calculational results were presented with comparisons to measured sample data. The results for PWRs were surprisingly good with C/E-1 values within 5-10% for many important isotopes while there were also isotopes that were orders of magnitude off the mark. No results were presented for BWRs due to difficulties inherent to the presence of voids and control rods (and their history effects).

It is very clear that the Studsvik code CASMO<sup>5</sup> continues to be the industry standard as it is used by ~75% of utilities worldwide. Studsvik utilizes constants derived from ENDF/B-VII.0 nuclear data and have data to enable tracking of ~800 fission products replacing the “fast” and “slowly-saturating” lumped fission product models of only a few years ago. As the total number of isotopes in ENDF/B-VII.0 is only ~400, it is clear that Studsvik has expanded their library to accommodate considerably more fission product cross-sections and adjusted these to measured data (at least at thermal energies).

<sup>4</sup> Expert Group on Assay Data of Spent Nuclear Fuel, *Spent Nuclear Fuel Assay Data for Isotopic Validation, State-of-the-art Report*, NEA/NSC/WPNC/DOC(2011)5. [http://www.oecd-nea.org/science/wpncs/ADSNF/SOAR\\_final.pdf](http://www.oecd-nea.org/science/wpncs/ADSNF/SOAR_final.pdf)

<sup>5</sup> <http://www.studsvik.com/Verksamhetsomraden/Driftoptimering/Programvara-for-bransleoptimering/In-Core-Fuel-Management/CASMO5/>

Monte Carlo depletion calculations using MCNP, SCALE and SERPENT are also being investigated. Based on the results presented, these methods appear currently feasible only on the two-dimensional sub-assembly – just a few pins with lots of symmetry – scale due to computer memory limitations and slow convergence of reaction-rates (or flux). Consequently, practical BWR multi-unit calculations may be impracticable without thousands of processors and full-parallelization such as is available in the LLNL code Mercury or the BAPL/KAPL code MC21. As of 2007, these codes represented the state-of-the-art<sup>6</sup> in R&D. However, these codes are not available to external users. For utilities, the state-of-the-art production method is still coarse mesh nodal diffusion codes (e.g., SIMULATE<sup>7</sup>) using constants generated from lattice codes (e.g., CASMO).

As a result of LLNL participation in the EGADNSF, we now have a list of the isotopes of interest for the burn-up credit community. As part of IER-147, we will attempt to utilize ISOCS software to identify and quantify as many of these isotopes of interest as possible from a Godiva-IV prompt burst irradiation using the Falcon 5000 HPGE gamma spectrometry system.

### **Burn-Up Credit**

The EGBUC provides no standard or recommendations as to “how to” actually take burn-up credit. The effort has been limited to code intercomparison studies using standard problems. Again, CASMO is the standard. There appears to be problems in the Monte Carlo depletion methods that relate to errors in fission product cross-sections (i.e., they have not been adjusted to produce measured isotopics in thermal spectra) as well as possible mistakes in the production and depletion chain rules in some codes. Most interestingly, there were significant problems related to burn-up step size. Predictor-corrector methods may need work. Also use of an average boron concentration may be no substitute for a more accurate representation of the boron “let-down” curve. The number of radial rings in poison rods is also an issue that presently only has *ad hoc* solutions.

Other calculations involved the extremely small worth of small individual fission product isotopic concentrations. Only APOLLO2 did well on calculating the fission product worth by perturbation methods. Unfortunately, there were no representatives from MCNP or SCALE to address problems with these methods. COG has a unique feature for “isotope biasing” that may be especially suited to calculating a small number of reactions for a special isotope of interest to the user. This feature could be further developed to enable a reactivity calculation. The CERES and CBU experiments in progress will provide benchmark quality experimental data that LLNL may attempt to simulate.

### **Governance of the WPNCS**

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<sup>6</sup> See page 23 of <http://www.oecd-nea.org/dbprog/documents/M%26C07Martin.pdf>

<sup>7</sup> <http://www.studsvik.com/Verksamhetsomraden/Driftoptimering/Programvara-for-bransleoptimering/In-Core-Fuel-Management/SIMULATE5/>

Mikey Brady-Raap is the current WPNCS chairperson. 15 countries plus the USA provided a report on their nuclear criticality safety national programs. Cecil Parks solicited information from the other US delegates in preparing the US report for presentation including my request to provide a brief description of the current status of the USDOE NCSP emphasizing the fact that COMET, FLATTOP, GODIVA and PLANET are operational in NCERC, which is a user facility.

The Chairs of the EGCEA, EGADSNF and EGBUC presented a summary of their meeting accomplishments this week and path forward. Ms. Tatiana Ivanova (IRSN) presented the agenda of the Expert Group on Uncertainty Analyses for Criticality Safety Assessment (EGUACSA) that will be meeting later in the month in Moscow in conjunction with the IRPHE Meeting. The Chair of the ICSBEP (Blair Briggs, not present) provided a presentation summarizing the results of the previous meeting in May 2013. No mention was made of the delay in publication by OECD of the ICSBEP DVD or updating their online version, which was discussed in a side bar meeting with Ian Hill (OECD) as reported in the LLNL FY2013Q4 IP&D QPR. No presentation materials were available for the Expert Group on Advanced Monte Carlo Techniques (EGAMCT), which will also meet in Moscow.

Brady-Raap announced the schedule and preliminary agenda for the ICNC 2015 conference to be held at the Omni Charlotte Hotel in Charlotte, North Carolina on September 14-18, 2015.

Finally, the Japanese delegation reiterated their formal invitation to host next year's WPNCS and any or all of the associated Expert Group meetings in conjunction with the PHYSOR meeting in Kyoto, Japan<sup>8</sup>.

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<sup>8</sup> <http://physor2014.org/>

ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT

Nuclear Energy Agency

Nuclear Science Committee

Working Party on Nuclear Criticality Safety

**THE THIRTEENTH EXPERT GROUP  
ON CRITICALITY EXCURSION ANALYSIS**

NEA Headquarters, Issy-les-Moulineaux, France

**October 7, 2013 9:30 - 17:00**

**PROPOSED AGENDA**

1. Welcome and administrative items : Y. Miyoshi
2. Approval of the agenda : All
3. Review of actions from the previous meetings : Secretariat
4. Approval of the summary records of the previous meeting : All
5. Status of benchmark problem phase-II
  - Summary of Phase-II report : Y. Miyoshi
  - Calculation results of FETCH : P. Smith
6. Status of benchmark problem phase-III
  - Specification of benchmarks and calculation : Y. Yamane
7. Review of excise of geometry model.
  - Present status and preliminary summary : IRSN (to be defined)
  - Calculation results of AGNES : Y. Miyoshi
8. Status of new excise of Plutonium nitrate solution
  - Calculation results of AGNES : Y. Yamane
9. Discussion of criticality evaluation methods of Fukushima plants
  - Preliminary calculations of Fuel assemblies and / or Fuel debris : JAEA
  - Accident scenario of spent fuel storage pool : NRC (to be defined)
10. Any other business (next meeting) : All
11. Adjourn

**ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT  
NUCLEAR ENERGY AGENCY  
Nuclear Science Committee  
Working Party on Nuclear Criticality Safety**

**SEVENTH MEETING OF THE EXPERT GROUP ON ASSAY DATA  
FOR SPENT NUCLEAR FUEL**

NEA Headquarters (Room B), Issy-les-Moulineaux, France

**PROPOSED AGENDA**

**8 – 9 October 2013**

**Tuesday October 8, 2013**

Time	Topic	Presenter
09h30	1) Welcome	I. Gauld
10h00	2) Approval of the agenda and summary record from the fifth meeting 3) Review of actions from past meetings.	F. Michel-Sendis
10h00	4) Review of new or expected experimental data contributions (evaluated or un-evaluated) <i>a)</i> Revision of ARIANE DU1 evaluation with Hf pellets and plenum data	P. Ortego
11h00	<i>b)</i> Evaluation of REBUS Measurements on Sample M11 <i>c)</i> <i>Status of Spanish Assay Evaluations (TBC)</i>	C. Tore J. Conde
11h00-11h20	d) Lattice physics analysis of measured isotopic compositions of irradiated BWR 9x9 UO <sub>2</sub> fuel.	T. Yamamoto
11h00-11h20	Coffee break	
11h20	5) Status of SFCOMPO Development at NEA	F. Michel-Sendis
12h45	<i>a)</i> The New SFCOMPO Prototype Database	

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12h45-14h15	Lunch	
14h15-16h00	b) Progress on Spent Fuel Data Compilations c) Verification of captured data sets and Future Development	O. Cabellos / I. Gauld F. Michel-Sendis
16h00-16h20	Tea break	
16h20-18h00	d) Requested feedback on data and development priorities from users and SFCOMPO Task Force	All

**Wednesday October 9 2013**

<b>Time</b>	<b>Topic</b>	<b>Presenter</b>
09h30 11h15	7) Guidance Report for Evaluators a) Latest version of the report and discussion on modifications	I. Gauld / All
11h15-11h35	Coffee break	
11h35 13h00	8) Presentations a) Studsvik Scandpower experience in core analysis and impacts on modelling uncertainties b) New Depletion Uncertainty Analysis Tools c) Spent fuel isotope ratios as nuclear forensics signatures.	M. Kruners I. Gauld F. Gey
13h00 13h15	9) Any other business Adjourn	

Note : The meeting can be extended until 18:00 depending on needs for discussion.

**ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT  
NUCLEAR ENERGY AGENCY  
Nuclear Science Committee  
Working Party on Nuclear Criticality Safety**

**THE TWENTY-SECOND MEETING OF THE EXPERT GROUP ON BURNUP CREDIT  
CRITICALITY**

NEA Headquarters, Room B, Issy-les-Moulineaux, France

**PRELIMINARY AGENDA**

**Thursday October 10 2013**

**NEA Room B  
9:30 am – 6:00 pm**

1. Welcome - *M. Brady-Raap*
2. Approval of the agenda – *Secretariat*
3. Approval of the Summary Record from the past meeting – *Secretariat*
4. Status of actions from last meeting – *M.Brady-Raap*
5. Status of the Summary report on Burnup Credit - *M.Brady-Raap / All*
6. Status of the Handbook report on Burnup Credit Criticality – *A. Scurlock*
7. Phase II-E benchmark report – *J.C. Neuber*
8. Phase III-C benchmark results and status of report - *K. Suyama*
9. Phase VIII benchmark results and status of report – *P. Leconte*
10. “*SCALE 6.1.2 - some comments to possible models of assembly for criticality and inventory calculation*” – *V. Chrapciak*.
11. “*Application of burnup credit with heterogeneous fuel loading at Paks NP*” – *G. Hordosy*
12. Discussion on the future of EG-BUC. - *M. Brady-Raap, K. Suyama, All*
13. Any other business
14. Date and place of the next meeting
15. Adjourn

ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT  
Nuclear Energy Agency  
Nuclear Science Committee

**17th Meeting of the Working Party on Nuclear Criticality Safety**

NEA Headquarters, Issy-les-Moulineaux  
Room B

Friday October 11 2013, 9:00 – 18:00

**PROPOSED AGENDA:**

1. Welcome and administrative items- *M. Brady-Raap*
2. Review of actions from the previous meetings – *Secretariat*
3. Approval of the summary records of the previous meeting- *All*
4. Feedback from the Nuclear Science Committee Meeting- *J. Gulliford*
5. Nuclear Criticality Safety National Programmes -*All*
6. Reports from the WPNCS Expert Groups :  
*Advanced Monte Carlo Techniques Expert Group (EGAMCT) – J. Miss (TBC)*  
*Burnup Credit Criticality Expert Group (EGBUC)- M. Brady-Raap*  
*Assay Data for Spent Nuclear Fuel Expert Group (EGADSNF)- I.Gauld*  
*Uncertainty Analyses for Criticality Safety Assessment (EGUACSA)- T. Ivanova*  
*Criticality Excursions Analyses Expert Group (EGCEA) – Y. Miyoshi*  
*International Criticality Safety Benchmark Evaluation Project (ICSBEP) – B. Briggs*
8. Status of ICNC 2015- *M. Brady-Raap*
9. Any other business - *All*
10. Date and place of the next meeting - *Secretariat*
11. Adjourn