Los Alamos NATIONAL LABORATORY

Memorandum

To: Dr. Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-ESH-21
Thru: Joetta Goda, LANL NCSP Task Manager
From: Garrett McMath, NEN-2, MS B228
George McKenzie, NEN-2, MS B228
Jesson Hutchinson, NEN-2, MS B228
Symbol: NEN-2:23-031
Date: July 1, 2023

Subject: Report on Foreign Travel to Paris, France for participation in the 2023 Workshop of the Nuclear Science Committee (NSC) / Working Party on Scientific Issues and Uncertainty of Reactor Systems (WPRS) Task Force on Zero Power Reactors (ZPR), IRSN/LANL collaboration meeting, and the Working Party on Nuclear Criticality Safety (WPNCS)

Meeting Details

Attendees on behalf of NCSP from LANL

1. ZPR: Garrett McMath and Geordie McKenzie
2. IRSN/LANL: Dave Hayes, Jesson Hutchinson, Geordie McKenzie, and Garrett McMath
3. WPNCS: Alexander Clark Dave Hayes, Jesson Hutchinson, Geordie McKenzie, Garrett McMath, and Mike Rising.

Meeting Titles

1. *Workshop of the NCS/WPRS Task Force on Zero Power Reactors (ZPR)*
2. *IRSN/LANL Collaboration Meeting*
3. *The Working Party on Nuclear Criticality Safety (WPNCS)*

Meeting Locations

1. ZPR: IRSN, Fontenay-aux-Roses, Paris, France
2. IRSN/LANL: IRSN, Fontenay-aux-Roses, Paris, France
3. WPNCS: OECD/NEA Headquarters, Boulogne-Billancourt, Paris, France

Meeting Dates

1. ZPR: June 22-23, 2023
2. IRSN/LANL: June 27, 2023
3. WPNCS: June 26-29, 2023

Meeting Objectives

The ZPR workshop provided an opportunity to discuss the needs for new reactor physics experimental data and to evaluate possible courses of action to acquire that data. The workshop reviewed and discussed a series of interviews with industry, operators, and researchers on the needs of Zero Power Reactor community.

The IRSN/LANL collaboration meeting provided an in-person forum to discuss ongoing and future work being undertaken by LANL and IRSN for NCSP-funded work including ICSBEP benchmarks.

The WPNCS workshop consisted of subgroups meeting to discuss transport in random geometries, quantifying nuclear data uncertainties in spent fuel inventory, bias and correlated data in benchmarks, comparing burnup credit in criticality safety evaluations, and criticality safety country reports.

Purpose of Travel

Attendees from Los Alamos National Laboratory (LANL) traveled to Paris, France to attend the meetings in person at the IRSN and OECD/NEA Headquarters.

Garrett McMath and Geordie McKenzie attended the Zero Power Reactor workshop as SMEs from NCERC. Given the topic of the meeting they brought very relevant experience to the problems being evaluated by the group. Geordie and Garrett stayed and attended both the IRSN/LANL collaboration meeting as leads for several IERs that are currently collaborating with IRSN. They also attended the WPNCS meeting, Geordie as a reviewer and Garrett as an observer.

Dave Hayes and Jesson Hutchinson attended both the IRSN/LANL meeting as SMEs and leads on IERs. They also attended the WPNCS meeting as reviewers.

Mike Rising and Alex Clark attended the WPNCS meeting as reviewers.

Meeting Benefits to the NCSP

The goal of the ZPR meeting goal was to develop a plan to build a new ZPR facility to facilitate experimental data needs. By providing expertise and advice in this endeavor the LANL participants make it more likely to succeed. NCSP would benefit from another facility providing both international benchmark data and trained professionals in the field.

The IRSN/LANL collaboration meeting was very beneficial to the participants working on NCSP funded experiments with their IRSN colleagues. Plans were made for future proposals and work as well as technical discussions on on-going work.

The WPNCS meeting moved forward several benchmarks through discussion, debate, and future actions. Many of the experiments are at least partially funded by NCSP.

Meeting Summaries

Thursday, June 22nd, 2023 (ZPR Meeting – Day 1)

- After the registration and welcome Robert Jacqmin, the chair of the Task Force for ZPRs, discussed the history and current state of ZPRs in the opening presentation. He gave a call to action concerning the rapid decline in the number of operating ZPRs and the potential loss of experimental infrastructure and expertise. The goal is the production of a report by late 2023 detailing the findings of the task force through interviews and this workshop.
- Session 1 began with the NEA Secretariat, Oliver Buss giving a summary of the interviews the task force had performed with stakeholders in ZPRs (operators, experimentalists, and data curators and users) from government, regulators, industry, and research. Several NCSP-funded individuals were among the interviewees. After this summary, several presentations were given on historical lessons learned from ZPR operations, projected data needs that ZPRs could provide, and new capabilities and cooperation models. Geordie and Garrett contributed substantially to these discussions as there was a lot of interest in how NCERC operates and solves some of the issues discussed. Throughout the session several other operators presented the status of their ZPRs (ZED-2 and New STACY) as well as presentation on criticality safety and data preservation.
- Session 2 started in the afternoon and focused on projected needs that could be addressed by ZPR facilities. Again, a summary of the interviews related to this area were presented first, followed by invited presentations from regulators, operators, and industry professionals to describe the needs in their specific fields. There did appear to be a disconnect for the invited regulator as it was an IRSN employee who did not see themselves as a regulator. There was very constructive discussion regarding the education and training aspect provided by ZPRs and again many questions as to how the US, in general, and NCERC, in particular, incorporate training activities into their operations.
- After the meeting closed there was a no host dinner attended by most of the participants including Garrett and Geordie.

Friday, June 23rd, 2023 (ZPR Meeting – Day 2)

- Friday began with a recap of day 1 and a presentation by Thomas Miller from ORNL on new capabilities and cooperation models that could be employed in the next generation of ZPRs. This was paired with a summary of the interview data pertaining to this.
- Session 3 was split between presentations on new capabilities and cooperation models that have shown to be successful in ZPR operations. Presentation were given on the KUCA and UTR ZPRs in Japan, the LR-0 ZPR in Czech Republic, and the Venus and Venus-F in Belgium. Lastly there was a presentation from Euratom (which was more appropriate for the regulator discussion from Day 1 so there was quite of bit of discussion on how to realistically get a cooperative ZPR built for the EU) and an overview of the JHR ZPR which could potentially be a solution to meet the task force needs.
- There was a final wrap-up and a few more discussions on how to get funding for such an endeavor. Note: the task force is more than willing to perform more interviews if there are additional interested candidates.

Monday, June 26th, 2023 (WPNCS – Day 1)

- Subgroup 9: Transport in Random Geometries – The subgroup was led by Andrea Zoia and began with a presentation on their ICNC submission and follow-on report testing multiple codes/models on UO_2 and MOX fuel media in random geometries. Average chord length was used to vary the fuel chunks but each of the 4 modelers chose different randomization techniques. Three quantities, Beta-eff, neutron generation time, and multiplication were calculated. All the codes did a good job constraining the problem but there were noticeable differences. Beta-eff was determined to be the least sensitive to changing geometries;, neutron generation time and multiplication were highly sensitive. A lot of discussion followed the presentation, but it was primarily on the wording chosen to present the results. Actions were assigned for any follow-on comments and the meeting was adjourned.
- Subgroup 10: Nuclear Data Uncertainties Quantification on Spent Fuel Inventory – The subgroup led by Carmouze and Ichou began with a presentation of the ICNC paper on spent fuel inventory uncertainty. They discussed the large effort of 20 participants looking at 35 separate results for 28 different nuclide densities including k-inf and C/E, producing more than 1000 results to analyze. Quite a few discrepancies were found among the analyses. For example, Scale and Serpent differed by almost 500 pcm at beginning of life. Additionally, standard deviations of greater than 4% were found for U-235, Am-242m, Am-243, Pu-238, Sm-149, and Cm isotopes. Greater than 10% standard deviations Were found for U-234, Am-241, Np-237, Sm-147, Pm-147, and Rh-103. U-235 significantly affected by burnup at high GWd. Due to the discrepancies an intermediate meeting was scheduled to discuss prior to ICNC. Lastly, Chris Perfetti, professor at University of New Mexico, gave a presentation on sensitivity coefficients for number density that his team has been developing. They are currently implementing the feature in OpenMC and doing initial testing. While the method sounds promising it is not fully developed.
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Tuesday, June 27th, 2023 (IRSN/LANL Meeting)

- Technical meetings took place at IRSN on a variety of subjects. Current NCSP projects included:
  - IRSN MOX Experiments (IER 296)
  - Godiva Shielding Benchmark (IER 498)
  - NeSO (IER 121)
  - MUSIC (IER 488)
  - EUCLID (IER 577)
- Several proposals for future work were also discussed including.
  - STACY experiments
  - Chlorine experiments (Cl-35(n,p), etc.)
  - LR0 experiments
  - Zirconium Test Assembly (ZTA)
  - Blind test dosimetry intercomparison

Wednesday, June 28th, 2023 (No Meeting)

- Due to lack of space at OECD, and limited expectation of meaningful contribution from the team, the team did not attend.

Thursday, June 29th, 2023 (WPNCS – Day 4)

- Subgroup 11: Bias and Correlated Data – Axel Hoefer from Framatome led this subgroup discussion and presented on the intercomparison exercise on bias and correlated data, comparison of methods. The ICNC paper has been drafted and with only a few minor actions left to be taken. The paper has 25 contributors from 16 organizations from 8 countries and is the basis for the OECD report. Much of the discussion revolved around the discussion of the results in chapter 5. There was some contention about the language used in relation to selection of benchmarks and validation methods having a large impact on the bias and uncertainty. However, it was determined that none of the methods used could be deemed inappropriate. Mike Rising made the case that the report should give a recommendation for certain cases and after some debate that was agreed upon. Final actions were assigned, and the session wrapped up with a proposal for a new benchmark by Ugur Mertyurek and Hany Abdel-Khalik for Data Assimilation Benchmark for Error Recovery and Quantification of Experimental Coverage. This benchmark would develop an exercise to test state of the art data assimilation techniques and quantify their ability to identify and adjust for embedded errors. The proposal was well received by the group and actions were laid out to move it forward.
- Subgroup 13: Comparison of Criticality Safety Evaluations and Burnup Credit approaches – Alexander Vasiliev led the subgroup and presented on the current benchmark status. First was a presentation on the motivation for the benchmark followed by the current status and expected outcome. The proposed benchmark exercise would use a 17x17 PWR UO2 fuel assembly with uniform fuel compositions corresponding to 9 different burnups and 4 different enrichments. Benchmarks have been selected using DICE. A survey for different options was given to the subgroup participants as an action to fill out. The session wrapped up with several presentations on current research on advanced USL methods, burnup credit for fuel storage at Framatome, IRSN prep work for the subgroup on the impact of data uncertainty on spent fuel assembly depletion for storage, and work done on the Duke PWR depletion reactivity benchmark. There was a small reception following the session which most of the group attended.

Attachment(s): Meeting agendas for each day

Copy: Doug Bowen, ORNL, bowendg@ornl.gov
John Miller, SNL, millerj@sandia.gov
Marsha Henley, ORNL, henleym@ornl.gov
Johnna Marlow, LANL, jmarlow@lanl.gov

Attachment 1: 2023 Workshop of the Nuclear Science Committee (NSC) / Working Party on Scientific Issues and Uncertainty of Reactor Systems (WPRS) Task Force on Zero Power Reactors (ZPR)

Thursday, 22 June 2023 – Lessons Learned and Needs			
ID	**Paris Time [CEST]**	**Agenda Item**	**Duration**
I	09:00	Registration on site Option to test Microsoft Teams connection for remote participants	00:15
II	**09:15**	**Welcome**	**00:20**
		- P. Giordano, Nuclear Safety Research Director, Institut de Radioprotection et de Sûreté Nucléaire (IRSN)	
		- T. Ivanova, Head of Division of Nuclear Science and Education, OECD Nuclear Energy Agency (NEA)	
III	**9:35**	**Presentation of NSC/WPRS Task Force on Zero Power Reactors** *R. Jacqmin, CEA (FRA)* *Chair of NSC/WPRS Task Force on Zero Power Reactors*	**00:20**
1	**10:00**	**Session 1: Lessons learned from the operation of ZPRs** *Chair: B. Merk*	
1.1	**10:00**	Summary of Interviews *NEA Secretariat*	00:20
1.2	**10:20**	Presentation User/Research - reactor experiments *D. Bernard, CEA (FRA)*	00:25
1.3	**10:45**	Presentation User/Research – shielding *T. Miller, ORNL (USA)*	00:25
	11:10	*COFFEE BREAK*	*00:20*
1.4	**11:30**	Presentation Operator/Research *"Canada's ZPR Experience: ZED-2", J.E. Atfield, B. Sur and L.R. Yaraskavitch, CNL (CAN)* *"Status of New STACY", G. Satoshi, JAEA (JPN)*	00:25
1.5	**11:55**	Presentation User/Research - criticality safety *C. Percher, LANL (USA)*	00:25
1.6	**12:20**	Invited Presentation Curator - data preservation, benchmarks *P. Blaise, CEA (FRA) and M. DeHart, INL (USA) [REMOTE]*	00:25
	12:45	*LUNCH BREAK*	*01:00*
1.7	**14:00**	Discussion	00:30
1.8	**14:30**	Wrap-Up Session I *R. Jacqmin, CEA (FRA)*	00:20

2	**14:50**	**Session 2: Projected needs related to new reactor physics experimental data and more** *Chair: B. Sur*	
2.1	**14:50**	Summary of Interviews *NEA Secretariat*	00:20
2.2	**15:10**	Invited Presentation - User/Industry *S. Franklin, NIRO (GBR) [REMOTE]* *B. Tomer, INL (USA) [REMOTE]*	00:25
2.3	**15:35**	Presentation - Regulator, TSO *S. Pignet, IRSN (FR)*	00:25
	16:00	*COFFEE BREAK*	*00:20*
2.4	**16:20**	Presentation - Operator/Research *A. Hawari, NCSU (USA) and L. Snoj, IJS (SLO) [REMOTE]*	00:25
2.5	**16:45**	Presentation - User/Research *D. Bernard and P. Leconte, CEA (FRA)* *A. Haghighat, Virginia Tech (USA) [Remote]*	00:25
2.6	**17:10**	Presentation - Education/Research *A. Buijs, McMaster University (CAN)* *V. Lamirand and O. Pakari, EPFL (CHE)*	00:25
2.7	**17:35**	Discussion	00:35
2.8	**18:10**	Wrap-Up Session II *R. Jacqmin, CEA (FRA)*	00:20
IV	**18:30**	**Closing Day 1**	
V	***19:30-22:00***	***Workshop Dinner***	

Friday, 23 June 2023 - Future			
	Paris Time [CET]	**Agenda Item**	**Duration**
VI	**09:00**	**Welcome Day 2 (and Recap Day 1)** *R. Jacqmin, CEA (FRA)*	**00:20**
3	**09:20**	**Session 3: New capabilities and cooperation models** *Chair: T. Miller*	
3.1	**09:20**	Summary of Interviews *NEA Secretariat*	00:20
3.2	**09:40**	Envisioning new experimental capabilities - Part 1 *B. Merk, University of Liverpool (GBR)*	00:30

		"Status of Critical Assembly (KUCA) and Training Reactor (UTR) in Japan", *C. H. Pyeon, Kyoto University (JPN) [REMOTE]*	
3.3	**10:10**	Envisioning new experimental capabilities - Part 2 *J. Wagemans, SCK-CEN (BEL) [REMOTE]* *M. Kostal, CV Rez (CZE) [REMOTE]*	00:30
	10:40	*COFFEE BREAK*	*00:20*
3.4	**11:00**	Organization and cooperation models - Part 1 *K. Tsuji, JAEA (JPN) [REMOTE]*	00:20
3.5	**11:20**	Organization and cooperation models - Part 2 *R. Garbil, European Commission*	00:20
3.6	**11:40**	Organization and cooperation models - Part 3 *G. Bignan, CEA (FRA) [REMOTE]*	00:20
3.6	**12:00**	Discussion	00:30
	12:30	*LUNCH BREAK*	*01:00*
3.7	**13:30**	Wrap-Up Session III *R. Jacqmin, CEA (FRA)*	00:30
VII	**14:00**	**Wrap-Up & Conclusions Workshop Days 1&2** *R. Jacqmin, CEA (FRA)*	**01:00**
VIII	**15:00**	**Closing Day 2**	

Attachment 2: The Working Party on Nuclear Criticality Safety (WPNCS)

Monday 6/26/2023 – SG 9

Time (CET)	Topic	Speaker
9:30	**Opening session**	
9:30	Welcome, opening remarks	A. Zoia (coordinator)
9:35	Self-introduction of participants	Participants
9:30	**Administrative items**	
9:30	Adoption of the agenda	NEA Secretariat
9:35	Approval of the summary record of previous meeting	NEA Secretariat
9:40	Review of actions from the previous meeting	A. Zoia (coordinator)
9:50	**Information**	
9:50	Status ICNC Submission	A. Zoia (coordinator)
10:00	**Status Report and Update of Activities**	
10:00	Status of the Report, Part 1	A. Zoia (coordinator)
10:30	Coffee/Photo	
10:50	Status of the Report, Part 2	A. Zoia (coordinator)
11:15	Discussion on recommendations from SG09	Participants
11:40	Discussion on outreach: conference presentations, journal articles, future work	Participants
11:50	Any other business	Participants
12:00	Review of actions	A. Zoia (coordinator)
12:15	Closing remarks	A. Zoia (coordinator)
12:30	**Adjourn**	
12:30	Lunch	

Monday 6/26/2023 – SG 10

Time (CET)	Topic	Speaker
14:00	**Opening session**	
	Welcome, opening remarks	C. Carmouze, R. Ichou (coordinators)
	Self-introduction of participants	Participants
	Review of actions from the previous meeting	Julie-Fiona Martin (NEA)
	Approval of SR from the previous meeting	Julie-Fiona Martin (NEA)
14:20	**Technical presentations**	
	SG10 results and issues	C. Carmouze, R. Ichou (coordinators)
15:00	Remaining comments from ICNC paper & Discussion	Participants
15:30	Group picture & Coffee break (30')	
16:00	**Report**	
	Current report version status	C. Carmouze, R. Ichou (coordinators)
	Planning for the final version	C. Carmouze, R. Ichou (coordinators)
16:40	**Other technical presentations**	
	Adjoint-Based Depletion Sensitivity Analysis in OpenMC	C. Perfetti
17:00	**Next steps**	
	Schedule for the next steps	C. Carmouze, R. Ichou (coordinators)
	Following subgroup proposal	C. Carmouze, R. Ichou (coordinators)
17:20	**Closing session**	
	Date and place of next meeting(s)	Julie-Fiona Martin (NEA)
	Any other business	Participants
	Review of actions	Julie-Fiona Martin (NEA)
	Closing remarks	C. Carmouze, R. Ichou (coordinators)
	Adjourn	

Thursday 6/29/2023 – SG 11

Time (CEST)	Topic	Speaker
9:00	**Opening session**	
9:00	Welcome, opening remarks	A. Hoefer, Framatome GmbH (GER) *(Coordinator)*
9:10	Self-introduction of participants	Participants
9:30	**Administrative items**	
9:30	Adoption of the agenda	NEA Secretariat
9:35	Review of actions from the previous meeting	A. Hoefer (Coordinator)
9:50	**Information**	
9:50	Status ICNC Submission	A. Hoefer (Coordinator)
10:00	**Status Report and Update of Activities**	
10:00	Status of the Report, Part 1	A. Hoefer (Coordinator)
10:30	Coffee/Photo	
10:50	Status of the Report, Part 2	A. Hoefer (Coordinator)
11:15	Discussion on recommendations from SG11	Participants
11:40	Discussion on outreach: conference presentations, journal articles, …	Participants
11:50	Data assimilation benchmark for error recovery and quantification of experimental coverage	U. Mertyurek, ORNL (USA)
12:10	Any other business	Participants
12:30	Review of actions	A. Hoefer (Coordinator)
12:40	Closing remarks	A. Hoefer (Coordinator)
12:50	**Adjourn**	
12:50	Lunch	

Thursday 6/29/2023 – SG 13

Time (CEST)	Topic	Speaker
14:00	**Opening session**	
14:00	Welcome, opening remarks	A. Vasiliev (Coordinator)
14:10	Self-introduction of participants	Participants
14:30	**Administrative items**	
14:30	Adoption of the agenda	NEA Secretariat
14:40	**Status Report and Update of Activities**	
14:40	Benchmark motivation	A. Vasiliev, A. Shama
15:00	Presentation of benchmark specification and expected outcome	A. Vasiliev (Coordinator)
15:20	Comparative analysis of standard and advanced USL methodologies for nuclear criticality safety	U. Mertyurek, W. B. J. Marshall
15:40	Coffee/Photo	
16:00	Burnup credit criticality safety analysis for high density spent fuel storage using a unified Bayesian validation methodology	A. Hoefer
16:20	IRSN preparatory work for SG13	F. Fernex
16:40	The DUKE PWR depletion reactivity measurements benchmarks applied to validation of SG13 calculation benchmarks	D. Mennerdahl
17:00	Final discussion on specifications	Participants
17:25	Discussion on outreach: conference presentations, journal articles, …	Participants
17:35	Any other business	Participants
17:45	Review of actions	A. Vasiliev (Coordinator)
17:55	Closing remarks	A. Vasiliev (Coordinator)
18:00	**Adjourn**	