

**OAK RIDGE NATIONAL LABORATORY
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**ORNL
FOREIGN TRIP REPORT
TA 445114**

DATE: October 18, 2019

SUBJECT: Foreign trip report for International Conference on Nuclear Criticality Safety (ICNC-2019)

TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Kursat B Bekar

**MEETING:
TITLE** 11th International Conference on Nuclear Criticality Safety

**MEETING:
LOCATION** Paris, FRANCE

**MEETING:
DATES** September 15-20, 2019

**ATTENDEES:
ON BEHALF
OF NCSP** Kursat Bekar, Doug Bowen, Justin Clarity, Travis Greene, Shane Hart, Ellen Saylor, William Marshall, and Will Wieselquist

**MEETING:
BENEFIT TO
NCSP** International Conference on Nuclear Criticality Safety brings together the nuclear criticality safety experts from all over the world every four years to discuss the technical, operational, and computational issues as well as the latest developments in the nuclear criticality safety area. Participation in this conference allows us to increase the awareness of the latest developments about modeling, simulation and analyses of the criticality safety problems and use the acquired information in our future development plans for the NCSP-sponsored radiation transport analysis tools within the SCALE code system to address the immediate needs in nuclear criticality safety applications. This is highly beneficial for NCSP to provide supports for the nuclear criticality safety applications with the state-of-the-art radiation transport tools.

**MEETING
PURPOSE:**

International Conference on Nuclear Criticality Safety brings together the nuclear criticality safety experts from all over the world every four years to discuss the technical, operational, and computational issues as well as the latest developments in the nuclear criticality safety area. Participation in this conference allows us to increase the awareness of the latest developments about modeling, simulation and analyses of the criticality safety problems and use the acquired information in our future development plans for the NCSP-sponsored radiation transport analysis tools within the SCALE code system to address the immediate needs in nuclear criticality safety applications.

**SITES
VISITED:**

ABSTRACT:

This trip was planned to attend two meetings, 11th International Conference on Nuclear Criticality Safety (ICNC), and the subgroup meetings of the Working Party on Nuclear Criticality Safety (WPNCS), and this report covers the first meeting, ICNC.

I have been developing and maintaining the CSAS (Criticality Safety Analysis Sequence) within the SCALE code system for a decade. CSAS is one of the most important analysis tools widely used around world in modeling, simulation and analyses of the nuclear criticality safety applications. During the ICNC meeting, I had opportunities to get valuable feedbacks from the international community about the success and limitation of our codes for some applications, and also learn some issues the other code systems were facing while being used in some challenging problems. This acquired information will be used to improve our product.

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REPORT OF FOREIGN TRAVEL

**Kursat B Bekar
Paris, France
October 18, 2019**

PURPOSE OF TRAVEL

Purpose of the travel was to attend the 11th International Conference on Nuclear Criticality Safety to acquire information about national and international issues and immediate needs in nuclear criticality safety area and using this information to make plans for the future developments and advancements activities for the radiation transport analysis tools within the SCALE code system for criticality safety applications.

Persons Contacted at <Location>

I met several participants, most of them from US (from other national laboratories, institutions, universities and NRC), and others from NEA, IRSN, CEA, GRS, and Wood. A list with all these participants can be provided if needed.

Itinerary

| | |
|---------------------|--|
| 09/14/19 – 09/15/19 | Travel from Knoxville, TN USA to Paris, FRANCE |
| 09/15/19 – 09/19/19 | Attend ICNC-2019 conference in Paris |
| 09/23/19 – 09/27/19 | Attend subgroup meetings of the Working Party on Nuclear Criticality Safety (WPNCs) – see separate trip report |
| 09/28/2019 | Travel from Paris, FRANCE to Knoxville, TN USA |

DISTRIBUTION

1. Doug G. Bowen (bowendg@orml.gov)
2. Angela Chambers (angela.chambers@mnsa.doe.gov)
3. Lori Scott (Lorisc0tt@aol.com)

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ORNL
FOREIGN TRIP REPORT
TA 442185

DATE: 11/11/2019

SUBJECT: Travel to ICNC 2019 in Paris, France
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Douglas Bowen

MEETING TITLE: ICNC 2019

MEETING LOCATION: Cité des sciences et de l'industrie, Paris, France

MEETING DATES: 09/14/2019 – 09/19/2019

ATTENDEES ON BEHALF OF NCSP: Douglas Bowen

MEETING BENEFIT TO NCSP: To present the latest in critical safety program technical expertise to the international community and to represent ORNL and NCSP on the international stage, to discuss the NCSP Mission and Vision and 5-year plan progress with international collaborators, to present papers on behalf of the NCSP, ISO and ANSI standards for nuclear criticality safety, and so share NCS expertise with meeting attendees.

MEETING PURPOSE: Conference of the global community of nuclear criticality safety experts.

SITES VISITED: City of Science and Industry, Paris, France

ABSTRACT: The goal of the trip was to attend International Criticality Safety Conference 2019 that was being held in Paris, France. As part of the conference I was exposed to the current research and proposals being conducted in the criticality safety world. I was the track leader for Track 5, "Track 5. Standards, Assessment Methodology, Regulations," presented four papers, executed an Expo booth in accordance with my duties as ISO TC85/SC5/WG8 convenor, conducted NCSP business with our international collaborators (AWE, IRSN, OECD/NEA, CEA, and JRC-Geel). I also mentored junior staff while at the conference and attended as many paper sessions as possible in my areas of interest, Nuclear Data and Nuclear Criticality Safety.

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REPORT OF FOREIGN TRAVEL

**Douglas G. Bowen
Paris, France
09/14/2019 – 09/20/2019**

PURPOSE OF TRAVEL

Attend the International Criticality Safety 2019 Conference being held in Paris, France.

Persons Contacted at the ICNC Meeting

I discussed conference details with many of the meeting attendees. I discussed ISO standards with members of my ISO WG8 committee and also held an official ISO TC85/SC5/WG8 meeting:

- Neil Harris (UK)
- Andy Sutton (UK)
- Ben Webborn (UK)
- Gregory Caplin (FR)
- Mathieu Duluc (FR)
- Luiz Leal (FR)
- Dennis Mennerdahl (SE)
- +Many others

I met with the NCS program IRSN lead, Stephane Evo to discuss NCSP collaboration business. I also met with CEA, with members of JRC-Geel, and AWE. Most of these meetings were to discuss NCSP business and continued collaboration. I also met with OECD/NEA, Tatiana Ivanova, regarding a new collaboration agreement with the NCSP.

Itinerary

| | |
|---------------------|--|
| 09/14/19 – 09/15/19 | Travel from Knoxville, USA to Paris, France. |
| 09/15/19 – 09/19/19 | Attend ICNC 2019 conference with focus on the methods and nuclear data tracks and to conduct ANSI/ISO and NCSP business. |
| 09/20/19 | Travel from Paris, France to Knoxville, USA. |

DISTRIBUTION

1. Douglas G. Bowen (bowendg@ornl.gov)
2. Angela Chambers (angela.chambers@mnsa.doe.gov)
3. Lori Scott (scottl@ornl.gov)

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**ORNL
FOREIGN TRIP REPORT
TA 442831**

DATE: 15-20 September 2019
SUBJECT: Attend 11th International Conference on Nuclear Criticality Safety (ICNC) meeting
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Chris W Chapman

MEETING: 11th International Conference on Nuclear Criticality Safety
TITLE

MEETING: Cité des sciences et de l'industrie; Paris, France
LOCATION

MEETING: Sunday, September 15 – Friday, September 20
DATES

ATTENDEES: Chris W. Chapman, William Marshall, Travis Greene, Doug Bowen, Justin Clarity,
ON BEHALF Shane Hart, Ellen Saylor, others from NCSU, IRSN, LANL, LLNL, and INL
OF NCSP

MEETING: Attendance to the ICNC conference is laid out in the 2019-2023 Five Year Plan
BENEFIT TO document. Dr. Chapman was responsible for presenting an update on the NCSP-
NCSP supported evaluation of ^{140,142}Ce.

MEETING As the pre-eminent conference devoted to criticality safety, the primary purpose is to
PURPOSE: meet with international collaborators and domestic NCS community and discuss
current and future topics of interest regarding nuclear criticality safety. Additionally,
some nuclear data topics were also discussed.

SITES Cité des sciences et de l'industrie, Paris, France
VISITED:

ABSTRACT: Oak Ridge National Laboratory is working on completing the resonance parameter evaluation of ^{140,142}Ce in the neutron energy range up to 200 keV. Performed with the support of the US Nuclear Criticality Safety Program, this evaluation aims to generate high-fidelity cerium cross-section and covariance data. A point-wise representation of the cross sections derived from the resonance parameters will provide improved calculations of self-shielding factors for nuclear criticality safety applications and additional evaluation support for continuous-energy radiation transport methodologies. The evaluation procedure uses the Reich Moore approximation of the R-matrix theory implemented in the SAMMY code system to fit resonance parameters to high-resolution transmission and neutron capture measurements of ^{nat}Ce

performed in 2016 by the JRC-GEEL instrument scientists at the Geel Linear Accelerator facility as well as other experimental data sets on both natural and highly-enriched cerium samples available in the experimental library EXFOR. In the analyzed energy range this work aims to improve and extend the resolved resonance region present in the latest US nuclear data library ENDF/B-VIII.0 for $^{140,142}\text{Ce}$ isotopes. This paper will present the preliminary results of the R-matrix analysis based on recently measured $^{\text{nat}}\text{Ce}$ transmission data.

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REPORT OF FOREIGN TRAVEL

**Chris W. Chapman
Paris, France
15-20 September 2019**

PURPOSE OF TRAVEL

Present paper about Cerium evaluation (funded by the NCSP) at the ICNC conference.

Persons Contacted at Cité des sciences et de l'industrie

The chair of the Nuclear Data track of the conference, Luiz Leal of IRSN. Several individuals in the nuclear data community from different institutions.

Itinerary

| | |
|-----------------------|---|
| 09/11/2019-09/12/2019 | Travel from Knoxville, USA to Paris, France |
| 09/15/2019-09/19/2019 | Paris France (ICNC) |
| 09/20/2019-09/20/2019 | Travel from Paris, France to Knoxville, USA |

DISTRIBUTION

1. Doug G. Bowen (bowendg@orml.gov)
2. Angela Chambers (angela.chambers@mnsa.doe.gov)
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ORNL
FOREIGN TRIP REPORT
TA 442832

DATE:
SUBJECT:
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM:

MEETING: 11th International Conference on Nuclear Criticality (ICNC)

TITLE

MEETING: Paris, France

LOCATION

MEETING: September 15th – 19th

DATES

ATTENDEES: Justin Clarity

**ON BEHALF
OF NCSP**

MEETING: This meeting discussed a number of the NCSP program components. Topics discussed included review of the latest advances in integral experiment design, development of new analytical methods for criticality safety analysis, development of sensitivity/uncertainty techniques for criticality safety validation and development of nuclear data and nuclear covariance data. All of these discussions allow me to be a better researcher and more effectively contribute to the NCSP mission.
**BENEFIT TO
NCSP**

**MEETING
PURPOSE:** The purpose of the meeting was to discuss recent advances in the field of criticality safety so that this can be applied at the respective facilities.

SITES

VISITED: Cité des sciences et de l'industrie, Paris, France

ABSTRACT: ICNC is the preeminent international meeting on nuclear criticality safety. This meeting discusses all relevant components of criticality safety analysis and analytical method development.

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REPORT OF FOREIGN TRAVEL

Justin Clarity
Paris, France
9/15/2019-9/20/2019

PURPOSE OF TRAVEL

The purpose of this travel was to attend the ICNC conference and to present three technical papers in the areas of criticality code validation, sensitivity/uncertainty analysis and critical experiment design. Additionally, the purpose was for me to attend technical sessions and learn what is being developed by other researchers in many areas of criticality safety.

Persons Contacted at ICNC

I met with many persons at the conference these included several researchers from other U.S. national laboratories as well as French, British, German and Japanese establishments.

Itinerary

9/13/2019 – 9/14/2019 Travel from Knoxville, USA to Paris, France
9/15/2019 – 9/19/2019 Attendance of ICNC
9/20/2019 – 9/22/2019 Personal time in Paris and Versailles, France
9/23/2019 – 9/24/2019 Travel from Paris, France to Knoxville, USA

DISTRIBUTION

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2. Angela Chambers (angela.chambers@mnsa.doe.gov)
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ORNL
FOREIGN TRIP REPORT
TA 443422

DATE: October 8, 2019
SUBJECT: ICNC 2019 Conference Report
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Travis Greene, Technical Professional Assistant Staff Member, Oak Ridge National Laboratory, PO Box 2008 MS6170, Oak Ridge, TN 37831-6170

MEETING: International Conference on Nuclear Criticality safety (ICNC)
TITLE
MEETING: Cité des sciences et de l'industrie, Paris, France
LOCATION
MEETING: September 15-20, 2019
DATES
ATTENDEES: Travis Greene
ON BEHALF
OF NCSP
MEETING:
BENEFIT TO
NCSP
MEETING
PURPOSE: Meeting purpose was to present a poster on an analysis of deuterium benchmark experiments as well as attend conference sessions and meet new people in the field of nuclear criticality safety.

SITES Cité des sciences et de l'industrie
VISITED:

ABSTRACT: **ANALYSIS OF D₂O BENCHMARK CRITICALITY EXPERIMENTS**

ABSTRACT

An analysis of systems containing deuterium was conducted using ICSBEP Handbook cases to address two areas of concern: first, prior reports of discrepancies for deuterium-moderated experiments with ENDF/B-VII.0 cross sections, and second,

difficulties encountered in SCALE with intermediate spectrum systems. Consequently, 89 cases from 16 evaluations utilizing deuterium as either a moderator or reflector were modeled using KENO V.a/VI, MCNP 6.1.1b, and SERPENT 2, with continuous energy (CE) and multigroup (MG) libraries (CE ENDF/B-VII.1, CE ENDF/B-VII, 252-group ENDF/B-VII.1). The models encompass differences in neutron energy (thermal, intermediate/mixed, fast), enrichment of $^{235/233}\text{U}$ (low, intermediate, high), and fissile material (solution, composite, metal). All cases were evaluated by C/E ratio and energy of average lethargy of fission (EALF).

The C/E values across all cases indicate a bias below 3.0%Δk with an average bias of 0.77%Δk. However, if the mixed/intermediate neutron energy spectrum cases are removed, the bias decreases to 1.83%Δk with an average of 0.57%Δk. No single code/library combination appears to outperform another as each differing combination arrives at similar results. While only ENDF/B-VII.1 was used to compare MG and CE libraries, an examination of the results indicates a wide range in the discrepancies between the two cross section libraries, with differences ranging from a maximum of 922 pcm to a minimum of 4.6 pcm, with an avg of 191 pcm.

Among all codes and libraries for each experiment within a case, the two largest differences occur in U233-COMP-THERM-004-001 (UCT), with a 961 pcm difference between MCNP and KENO, and in HEU-COMP-THERM-018-001 (HCT), with a 922 pcm difference between MG-KENO and CE-KENO. If UCT-004 and HCT-018 are excluded, the remaining 62 experiments show differences of less than 500 pcm with an average difference of 195 pcm.

Overall, the codes and libraries used for modeling these experiments tend to slightly overestimate LEU, metal, and thermal systems, while underestimating HEU, solution, compound, fast, and intermediate systems. The models here provide consistent results with variable uncertainties across a wide range of systems that utilize deuterium either as a moderator or reflector. The results form the basis for further exploration into deuterium systems. Other experiments could provide a more rigorous and complete picture of deuterium nuclear data performance.

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REPORT OF FOREIGN TRAVEL

**Travis Greene
Cité des sciences et de l'industrie, Paris, France
London, United Kingdom
Poole, United Kingdom
September 13 – 24, 2019**

PURPOSE OF TRAVEL

The purpose of the travel was to attend the 11th International Conference on Nuclear Criticality safety in Paris, France and to present a poster titled “Analysis of D₂O Benchmark Criticality Experiments.”

Persons Contacted at ICNC

No specific meetings with any one person were held; only brief interactions with conference members.

Itinerary

| | |
|---------------------|---|
| 09/13/19 – 09/14/19 | Travel from Knoxville, USA to Paris, France |
| 09/15/19 – 09/20/19 | Cité des sciences et de l'industrie, Paris, France (conference agenda attached) |
| 09/21/19 – 09/22/19 | London, United Kingdom to Poole, United Kingdom (personal days) |
| 09/23/19 | Poole, United Kingdom to Paris, France (personal day) |
| 09/24/19 | Travel from Paris, France to Knoxville, USA |

Conference agenda: <https://www.icnc2019.com/en/program/detailed-program/23>
(a pdf of the conference agenda will also be attached)

DISTRIBUTION

1. Doug G. Bowen (bowendg@orml.gov)
2. Angela Chambers (angela.chambers@mnsa.doe.gov)
3. Lori Scott (Lorisc0tt@aol.com)

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**ORNL
FOREIGN TRIP REPORT
TA 442841**

DATE: 10/04/2019
SUBJECT: Travel to ICNC 2019 in Paris, France
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Shane Hart

MEETING: ICNC 2019
TITLE

MEETING: Paris, France

LOCATION

MEETING: 09/15/2019 – 09/20/2019

DATES

ATTENDEES: Shane Hart

**ON BEHALF
OF NCSP**

MEETING: To present the latest in critical safety program technical expertise to the international community and to represent ORNL and NSCP on the international stage.

**BENEFIT TO
NCSP**

**MEETING
PURPOSE:** Conference of the global community of nuclear criticality safety experts.

SITES City of Science and Industry, Paris, France

VISITED: Melox Facility, Chusclan, France

ABSTRACT: The goal of the trip was to attend International Criticality Safety Conference 2019 that was being held in Paris, France. As part of the conference I was exposed to the current research and proposals being conducted in the criticality safety world. Most time was spent in the methods and data tracks as those are the areas to which I am most accustomed. In addition, I attended a technical tour that was held at the Melox facility in Chusclan, France. This facility produces MOX fuel for use both in France and internationally. It was a learning experience as I had never been to a fuel production facility before.

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REPORT OF FOREIGN TRAVEL

**Shane Hart
Paris, France & Chusclan, France
09/13/2019 – 09/21/2019**

PURPOSE OF TRAVEL

Attend the International Criticality Safety 2019 Conference being held in Paris, France and go on a technical tour of the Melox MOX production facility in Chusclan, France.

Persons Contacted at Chusclan, France

Olivier Ravat: +33 4 66 90 64 48

Itinerary

| | |
|---------------------|--|
| 09/13/19 – 09/14/19 | Travel from Knoxville, USA to Paris, France. |
| 09/15/19 – 09/19/19 | Attend ICNC 2019 conference with focus on the methods and nuclear data tracks. |
| 09/19/19 – 09/20/19 | Visit the Melox MOX fuel production facility in Chusclan, France. |
| 09/21/17 | Travel from Paris, France to Knoxville, USA. |

DISTRIBUTION

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2. Angela Chambers (angela.chambers@mnsa.doe.gov)
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ORNL
FOREIGN TRIP REPORT
TA 443028

DATE: October 10, 2019
SUBJECT: Trip report for International Conference on Nuclear Criticality Safety
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Dr. William J. Marshall

MEETING: 11th International Conference on Nuclear Criticality Safety
TITLE
MEETING: Paris, France
LOCATION
MEETING: September 15-20, 2019
DATES
ATTENDEES: William Marshall, Justin Clarity, Ellen Saylor, Travis Greene, Shane Hart, Will
ON BEHALF Wieselquist, Kursat Bekar, and Doug Bowen
OF NCSP

MEETING: The International Conference on Nuclear Criticality Safety is the preeminent
BENEFIT TO quadrennial conference related to Nuclear Criticality Safety. Participation in
NCSP this conference helps disseminate best practices for modeling, simulation, and
practice of criticality safety around the world as well as learn best practices
from other sites and nations. Participation thus promotes the reputation of the
NCSP around the world.

MEETING The International Conference on Nuclear Criticality Safety is the preeminent
PURPOSE: quadrennial conference related to Nuclear Criticality Safety. Participation in
this conference helps disseminate best practices for modeling, simulation, and
practice of criticality safety around the world as well as learn best practices
from other sites and nations.

SITES Paris, France and the ORANO La Hauge Fuel Cycle Facility in La Hague, France
VISITED:

ABSTRACT: The trip to France had two distinct purposes and was split into two pieces: September 15-20 to attend the 11th International Conference on Nuclear Criticality Safety (ICNC) and September 23-27 to attend the subgroup meetings of the Working Party on Nuclear Criticality Safety (WPNCS). This trip report covers the first week and ICNC. I was the lead author of three papers at ICNC, one of which was presented orally and the other two were presented as posters. I provided the oral presentation and one poster, and Ellen Saylor presented the other poster. I also chaired three sessions, one each in the tracks dedicated to Uncertainty and Sensitivity Analysis; Measurements, Benchmarks, and Experiments; and Storage and Transport Issues. On Friday, September 20, I participated in a tour of the ORANO La Hague Fuel Cycle Facility. This tour provided the opportunity to see an industrial reprocessing plant and discuss some of the criticality and radiological safety issues associated with plant design and operations.

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REPORT OF FOREIGN TRAVEL

**William J Marshall
Paris and La Hague, France
October 10, 2019**

PURPOSE OF TRAVEL

The purpose of the travel was to attend the 11th International Conference on Nuclear Criticality Safety. I presented a paper and a poster at the meeting and chaired 3 sessions.

Persons Contacted

A complete list of conference attendees can be provided if desired, but no specific list of all persons with whom I interacted could be reasonably or accurately generated.

Itinerary

| | |
|----------------|--|
| 9/14/2019 | Depart Knoxville, TN |
| 9/15/2019 | Arrive Paris |
| 9/15-9/19/2019 | Attend conference in Paris |
| 9/19-9/20/2019 | Participate in technical tour of ORANO La Hague Fuel Cycle Facility |
| 9/23-9/26/2019 | Attend subgroup meetings of the Working Party on Nuclear Criticality Safety (WPNCS) – see separate trip report |
| 9/27/2019 | Return to Knoxville, TN |

DISTRIBUTION

1. Doug G. Bowen (bowendg@orml.gov)
2. Angela Chambers (angela.chambers@mnsa.doe.gov)
3. Lori Scott (Lorisc0tt@aol.com)

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**ORNL
FOREIGN TRIP REPORT
TA 443089**

DATE: October 15, 2019
SUBJECT: Foreign Trip Report for ICNC 2019
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Ellen M. Saylor

MEETING: 11th International Conference on Nuclear Criticality Safety, ICNC 2019

TITLE

MEETING: Paris, France

LOCATION

MEETING: September 15-20, 2019

DATES

ATTENDEES: Doug Bowen, Justin Clarity, Chris Chapman, Shane Hart, William B.J. Marshall,
ON BEHALF Travis Greene, and Ellen Saylor (listed are from ORNL, others from other sites not
OF NCSP listed)

MEETING: The International Conference on Nuclear Criticality Safety is the preeminent
BENEFIT TO quadrennial conference related to Nuclear Criticality Safety. Participation in this
NCSP conference helps disseminate best practices for modeling, simulation, and practice of criticality safety around the world as well as learn best practices from other sites and nations. Participation thus promotes the reputation of the NCSP around the world.

MEETING The International Conference on Nuclear Criticality Safety is the preeminent
PURPOSE: quadrennial conference related to Nuclear Criticality Safety. Participation in this conference helps disseminate best practices for modeling, simulation, and practice of criticality safety around the world as well as learn best practices from other sites and nations.

SITES Paris, France and CEA Cadarache Research Center in Saint Paul Les Durance, France
VISITED:

ABSTRACT: This trip was to attend the 11th International Conference on Nuclear Criticality Safety (ICNC). I was a co-author of a paper that I presented in the poster session and attended various sessions on relevant nuclear criticality safety issues. On Friday, September 20, I participated in a tour of the CEA Cadarache Research Center. This tour provided the opportunity to tour their materials testing reactor (still under construction), a decommissioned reactor, and their hot cells facility and discuss some of the criticality and radiological safety issues associated with design and operations.

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REPORT OF FOREIGN TRAVEL

**Ellen M. Saylor
Paris and Saint Paul Les Durance, France,
September 15-20, 2019**

PURPOSE OF TRAVEL

Participation in international criticality safety community – attending presentations, representing poster in poster session, participating in discussions on nuclear criticality safety program tasks and relevant nuclear criticality safety issues.

Persons Contacted

See attached list of attendees. While not all persons listed were directly contacted or interacted with, all were present at the venue.

Itinerary

| | |
|---------------------|--|
| 09/13/19 – 09/14/19 | Travel from Knoxville, USA to Paris, France |
| 09/15/19 – 09/19/19 | Attend ICNC in Paris |
| 09/19/19 – 09/20/19 | Participate in technical tour of CEA Cadarache Research Center in Saint Paul Les Durance |
| 09/23/19 | Travel from Paris, France to Knoxville, USA |

DISTRIBUTION

1. Doug G. Bowen (bowendg@orml.gov)
2. Angela Chambers (angela.chambers@mnsa.doe.gov)
3. Lori Scott (Lorisc0tt@aol.com)

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ORNL
FOREIGN TRIP REPORT
TA 446004

DATE: 2019-10-01
SUBJECT: Trip Reports for 2019 ICNC and WPNCS
TO: Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, Pantex Plant, PO Box 30020, Amarillo, TX 79120-0020

FROM: Will Wieselquist

MEETING: International Conference on Nuclear Criticality Safety (ICNC) 2019 and Working
TITLE Party for Nuclear Criticality Safety (WPNCS) at OECD/NEA
MEETING: Paris, France

LOCATION
MEETING: 09/14/2019 – 09/28/2019

DATES
ATTENDEES: Will Wieselquist

ON BEHALF
OF NCSP

MEETING: The benefits to NCSP include, as director of the SCALE code system, I am
BENEFIT TO more easily able to address the needs of the community if I am current with
NCSP domestic and international issues in nuclear criticality safety and able to communicate in person with the relevant parties. Also, mainly with regard to the week at WPNCS, this visit enables me to participate in decision making and planning related to nuclear criticality safety within the working party, and integrate this information into priorities for development within the SCALE code system.

MEETING Attend ICNC and WPNCS. Participate in discussion and planning.
PURPOSE:

SITES Week 1: ICNC Conference Center
VISITED: Cité des sciences et de l'industrie
30, avenue Corentin-Cariou
75019 Paris

FRANCE

Week 2: OECD/NEA Headquarters
46, quai Alphonse Le Gallo
92100 Boulogne-Billancourt
FRANCE

ABSTRACT:

This trip report documents two weeks spent in Paris supported by NCSP: the first at the ICNC conference and the second at the WPNCS meeting. The agenda included describes the most useful and relevant information gained. My main goal as the new director of the SCALE code system was to understand better the current issues in criticality safety so as to direct our efforts to better support this specific community of users. I have much more experience in the reactor physics side of things so this was a great opportunity to understand another aspect of nuclear engineering.

The following are my action items resulting from this trip.

- Develop a way to assess the performance of WHISPER vs. SCALE methods to more clearly highlight advantages/disadvantages. Currently, I think the ideal way to compare methods is to remove a single case from the validation set, treat that case as an application, predict the bias in that case from all others, and compare to the true bias.
- Develop documentation/examples/training/additional tools to make the SCALE bias prediction easier to use. Is this a better connection to DICE? What are the needed tools?
- New nuclear data evaluations such as Thermal Scattering Laws for ice and Gadolinium isotopes need to have proper SCALE performance assessments.
- Results for Sub-Group 3 at WPNCS on understanding effects of ice on transport and storage calculations should be presented, perhaps in a clarified form, to SCALE users.
- Source convergence analysis and acceleration techniques in production SCALE need to be more clearly documented—they may be comparable to **new, unreleased** techniques in MCNP but most SCALE users do not know about them. Additional convergence diagnostics should be investigated.
- I will lead a new Sub-Group 8 to better categorize benchmarks by usefulness for a specific purpose and collect more information on ICSBEP benchmarks, especially from experts, to disseminate to the entire community.

Access to the information in this report is limited to those indicated on the distribution list and to U.S. Government Agencies and their Contractors.

REPORT OF FOREIGN TRAVEL

**Will Wieselquist
Paris, France
09/14/2019 – 09/28/2019**

PURPOSE OF TRAVEL

The purpose of this travel was to, as director of the SCALE code system, understand current domestic and international issues in nuclear criticality safety. By communicating in person with practitioners and researchers and attending their presentations, I am more easily able to understand the needs of the criticality safety community, especially given my background in reactor physics, which would not normally bring me to the ICNC conference. Also, mainly with regard to the week at WPNCS, this visit enabled me to participate in decision making and planning related to nuclear criticality safety within the working party, and integrate this information into priorities for development within the SCALE code system.

Persons Contacted

Contact was limited to conference attendees at ICNC and working party participants at WPNCS. Some new relationships established in a criticality safety context follow.

- John Bess
- Catherine Percher
- Axel Hofer
- Sonny Gan
- Paul Smith
- Stephane Evo
- Coralie Carmouze
- Fabian Sommer
- Michael Rising
- Luiz Leal
- Josh Hykes
- Dennis Mennerdahl

Itinerary

09/14/19 – 09/15/19 Travel from Knoxville, USA to Paris, France

ICNC, Paris, France (day-by-day agenda)

09/16/19 morning Attended ICNC Plenary. Gained an appreciation for criticality safety needs in front-end and back-end, including storage.

09/16/19 afternoon Attended Nuclear Data (Track 2). Thermal scattering law (TSL) data was the subject of many talks. Interesting results below.

- Including TSL data for U and O in UO₂ can decrease reactivity by 100 pcm.

- New updates of U234, U236 (important impurities in some systems) may have impact on criticality safety calculations.
 - There is little impact of TSL on reactivity swing observed in depletion calculations between different data libraries (ENDF/B vs. JEFF).
- 09/17/19 morning Attended Sensitivity Uncertainty (Track 3). Most interesting was understanding the WHISPER S/U approach and how it relates to the SCALE approach. Although I believe the SCALE approach is more mathematically rigorous and leads to greater insight on biases, the WHISPER system is undoubtedly easier to use and appears more conservative. There should be a more rigorous way to assess the performance of these two methods—and improve the ease of use for the SCALE approach.
- 09/17/19 afternoon Attended Nuclear Data (Track 2). Highlights in this track were Luiz Leal’s presentation of work on new evaluations for Gadolinium isotopes. This has considerable overlap between criticality safety and reactor physics and we will have a task in SCALE to evaluate the performance of this new data. Also the talk of a temperature effect on resonance uncertainties was interesting in understanding a temperature effect we are currently neglecting in the uncertainty representation.
- 09/18/19 Attended Measurements, Experiments, and Benchmarks (Track 4). Highlights in this track include new experiments (IER 209, TEX, BUCCX), which can provide SCALE with useful validation cases for both criticality safety and reactor physics. A method was presented for using cold criticals in a BWR for validation. The proposed ICSBEP benchmark based on TREAT has some significant composition uncertainties (hydrogen and boron in graphite) that should limit its applicability to code validation.
- 09/19/19 morning Attended Measurements, Experiments, and Benchmarks (Track 4). Highlights in this track were the consideration of experiments at higher temperature and lower moderator density. These are extremely valuable for code validation.
- 09/19/19 afternoon Attended workshop on “Enhancing Validation of Nuclear Criticality Safety Calculations with ICSBEP Handbook and NEA Tools”. Gained an appreciation for the depth of capabilities of NEA tools, mainly in DICE, although the learning curve is quite steep. Also, the data used internally is sparse and outdated. There’s a need for timely (ideally automated) update of the sensitivity and benchmark data. Also gained an appreciation for the enormous content of the ICSBEP handbook.
- 09/20/19 Worked from hotel in Paris, focusing on planning activities for NCSP and follow-up reading of ICNC papers.
- 09/21/19-09/22/19 Personal days.

OECD/NEA Headquarters, Paris, France (day-by-day agenda)

- 09/23/19 morning Attended meeting of Sub-Group 4, Analysis of Past Criticality Accident. The majority of the time was spent presenting the Windscale Works Incident where unknown organic content in an aqueous solution tank caused an approximately 10-second criticality event. The event was particularly interesting in that it happened when new aqueous solution was added to the tank, which flowed through the organics, temporarily creating an emulsion of a specific shape that resulted in criticality. The criticality self-terminated as the emulsion settled. Discussion centered on the usefulness of the benchmark, ability for participants to model it, and necessary specifications. Does it require coupled fluid dynamics

or should we impose a conic shape of the emulsion and ensure that codes predict this as a critical configuration? There are lots of missing details. After talking to others at lunch, the design of modern holding tanks (annular or long, thin) prevents this kind of incident and the remarkable amount of contaminants present makes it an interesting historical occurrence but not safety-relevant by current standards.

09/23/19 afternoon

Attended meeting of Sub-Group 3 on the effect of temperature on the neutron multiplication factor for PWR fuel assemblies, which includes analysis of new thermal scattering data for ice. Dennis Mennerdahl, Marion Tiphine, BJ Marshall, and Paul Smith all presented work from EMS, CEA, ORNL, and Wood, respectively. Sonny Gan of Sellafield coordinated and presented quite a few results, with the only outlier being a deterministic code submission. All evidence clearly indicates the density effect of ice vs. water trumps the temperature/scattering kernel effect significantly. Offline, I discussed with BJ Marshall that the test case chosen is not ideal for demonstrating the effect of ice data on simulations. We will create a small set of SCALE cases to show the effect more clearly.

09/24/19 morning

Attended meeting of Sub-Group 2, Blind Benchmark of MOX damp powders. The main purpose of this activity, as I understood it, was to investigate bias predictions with various tools for scenarios with little validation data, such as MOX damp powders. Although criticality in MOX damp powders is interesting, I would have suggested a different approach if bias prediction is the underlying goal. In my opinion, the ideal way to compare methods is to remove a single case from the validation set, treat that case as an application, predict the bias in that case from all others, and compare to the true bias.

The MONK team (Wood) had an interesting multi-category matching scheme for assessing similarity based on low/medium/high similarity rankings for 6 categories:

- Type of fissile material
- Non-fuel absorption
- Leakage
- Resonance absorption
- Fast fission
- Hydrogen content.

They are in the process of converting from low/medium/high to a number in [0,1]. The MONK team also has two tiers of validation inputs, a rigorously QA-ed tier and a kind of “initial QA performed” tier. I believe this is a good approach for validation suites, for example with VALID we have a very large cost to get something from ICSBEP into the suite. In many cases, I would prefer to spend 100K on new VALID cases and get 1 “class A” benchmark and 10 “class B” benchmarks versus 2 “class A” benchmarks.

This discussion led into the need to identify certain ICSBEP benchmarks as non-ideal for certain purposes, such as bias prediction or code validation, due to known issues. This resulted in a proposal (later accepted) for Sub-Group 8, led by Wieselquist at ORNL to better categorize benchmarks by usefulness for a

specific purpose and collect more information on ICSBEP benchmarks, especially from experts, to disseminate to the entire community.

09/24/19 afternoon

Attended meeting of Sub-Group 7 on the definition of a benchmark on sensitivity/uncertainty analyses on used fuel inventory. This benchmark had chosen a difficult-to-model sample from Gosgen where the fuel rod had been moved from one assembly to another in its 3rd cycle. The participants discussed how much modeling information to mandate in order that participants contribute comparable results. With fairly extensive experience in depletion validation, I recommended to do a simpler case as well as let participants choose modeling parameters to yield minimal extra calculation bias with respect to experimental uncertainty, according to their chosen codes and methods.

This sub-group will likely have 3 stages. In the current stage, the benchmark will be defined and a report produced. In the second 2-year period, a single depletion calculation will be performed. In the third 2-year period, the sensitivity/uncertainty calculation will be performed. This analysis should integrate somehow with SFCOMPO.

09/25/19 morning

I did not attend Sub-Group 5, Experimental needs for criticality safety purposes, as I thought I had seen most of it at ICNC. Instead, I caught up on SCALE-related managerial duties from the hotel.

09/25/19 afternoon

Attended Sub-Group 6, Statistical tests for diagnosing fission source convergence and undersampling in Monte Carlo criticality calculations. This was essentially the same content as the MCNP (LANL) talk by Forest Brown at the 2019 NCSP TPR and so I won't summarize here.

The MONK (Wood) methodology relied on a clever fission site convergence test where you check the nearest neighbors on successive generations and once the distribution of nearest neighbors converges, you declare the source distribution has as well. They also investigated differential entropy.

I believe SCALE needs to actively show more capability in this area. With criticality calculations, we give the user details on how results would change if you had chosen a different number of inactive generations. With this printout and other standard convergence checks, a novice CSAS user can easily avoid issues in k-eff results due to source convergence issues. However, for other tallies, e.g. flux/reaction rate, CSAS does not provide this type of information. Also, CSAS has fairly sophisticated starting sources, including one from a voxelized deterministic calculation constructed directly from the user-input geometry. This starting source should be as effective at accelerating source convergence as anything presented by Forest for MCNP, and it is available in the current 6.2.3 release. However, it is clear from Forest's talk that there are additional source convergence metrics that could be added to SCALE. In particular the meshing selection based on mean distance to fission seemed like a valuable automation.

09/26/19

I did not attend Sub-Group 1, Role of Integral Experiment Uncertainties and Covariance Data in Criticality Safety Validation. B.J. Marshall was attending and I am very familiar with this work and do not have much to contribute at this late

stage in the effort. Instead, I worked on the Sub-Group 8 proposal and other SCALE managerial activities.

09/27/19 Attended the WPNCS meeting where the various sub-groups were summarized, country update reports were given, the ICNC 2023 location was announced (Sendai, Japan), and the new Sub-Group 8 which I will lead was voted on and accepted.

09/28/19 Travel from Paris, France to Knoxville, USA

DISTRIBUTION

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