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Working Party on Nuclear Criticality Safety

21st Meeting of the Working Party on Nuclear Criticality Safety (WPNCS)

SUMMARY RECORD

26-30 June 2017
NEA Headquarters, Boulogne-Billancourt, France

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OECD Nuclear Energy Agency
Nuclear Science Committee

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26-30 June 2017

NEA Headquarters, Room BB1
46, quai Alphonse Le Gallo
Boulogne-Billancourt, France

The Working Party on Nuclear Criticality Safety (WPNCS), and its five associated Expert Groups met during the week of 26-30 June 2017 at NEA Headquarters:

- The Expert Group on Criticality Excursions Analyses (EGCEA)
- The Expert Group on Assay Data of Spent Nuclear Fuel (EGADSNF)
- The Expert Group on Burn-up Credit Criticality (EGBUC)
- The Expert Group on Uncertainty Analyses for Criticality Safety Assessments (EGUACSA)
- The Expert Group on Advance Monte Carlo Techniques (EGAMCT)

1. Introduction and Welcome

Apologies were received from the outgoing WPNCS Chair, E. Létang (IRSN), for not being able to attend the meeting. On his behalf, Franco Michel-Sendis opened the meeting and acknowledged the Chair's valuable work and contribution to the working party. Mr Létang is stepping down of the WPNCS Chairmanship due to his change in functions in his home institution. Elected as new Chair, Stephane Evo (IRSN), welcomed the participants, who briefly introduced themselves. The meeting was attended by twenty-three participants from Canada, France, Finland, Germany, Japan, Korea, Russia, Sweden, Switzerland, the UK and the US (see participant list in Annex C).

2. Review of Actions from Previous Meeting

There were no outstanding actions to review.

3. Approval of the Previous Summary Record and Agenda

The summary record of the previous meeting was approved and country reports that had been submitted were included. The agenda (Annex B) was approved without any modification.

4. Feedback from the Nuclear Science Committee Meeting

T. Ivanova (Head of Division of Nuclear Science) reported on the outcomes of the last NSC meeting held on 31 May-2 June 2017. She informed the working party members that the OECD Council agreed to invite Argentina and Romania to become full members of the NEA. She gave an overview of progress and future directions in Nuclear Science. She mentioned that there is a link between the outputs of the Programme of Works of the Data Bank and Nuclear Science in the areas of nuclear data testing, benchmarking and validation. Moreover, it was highlighted that different outputs from activities in other NEA divisions along with NI2050 were incorporated into the nuclear science area and further focus would be placed on strengthening links with CSNI activities and NI2050.

Also, she highlighted the importance of the establishment of a new activity within the nuclear science area, which aims to support advanced experimental capacities for deployment of nuclear innovation. A special session of the NSC meeting was held on 2nd June 2017 to discuss the NSCs role in providing experimental support in facilitating the deployment of innovative components in existing and future nuclear power systems. Presentations from several institutions gave examples of new experimental capabilities in the USA and Europe. How to efficiently link experimental validation and qualification to the development and licensing of innovative fuels and materials was discussed. The NSC gave its endorsement to establish a platform aimed at enhancing experimental support, facilitating deployment of innovative components in nuclear power systems. It was decided that the first step towards implementation of a platform is to hold a kick-off Workshop in January 2018. The Workshop will bring together representatives from industries, research laboratories, regulatory organisations and nuclear fuel vendors to discuss ways to advance the work on deploying innovative fuels and materials, and in particular, accident tolerant fuels.

She also pointed out that a new subgroup was created within WPEC on nuclear data covariances at the request of WPRS.

Finally, she announced the departure of three staff members of the Division of Nuclear Science, Simone Massara, Yukio Nakahara and Oscar Cabellos, adding that Davide Costa, a staff member currently on a post in the Data Bank, will take over from Simone Massara.

5. Feedback from the Management Board for the Development, Application and Validation of Nuclear Data and Codes (MBDAV)

J. Gulliford (Head of Data Bank) reported on the outcomes of the MBDAV meeting held on 29-30 May 2017. He pointed out that, in follow-up to the recommendations by the Data Bank Task Force, it was decided to rename the Executive Group of the Nuclear Science Committee (NSC/EG) the Management Board for the Development, Application and Validation of Nuclear Data and Codes (MBDAV). This new governing body for the Data Bank reports directly to the Steering Committee.
J. Gulliford noted that MBDAV co-operates very closely with NSC in several areas, such as evaluated nuclear data, integral experiments and benchmarks validation, emphasising the new role of MBDAV in the area of benchmarking and validation. He summarised the main developments that have come out since the creation of the MBDAV, highlighting the two key recommendations discussed at the second MBDAV meeting in February 2017. He also gave an overview of the outcome of the first CPS Task Force meeting held on 19 May 2017, where it was agreed that validation area would be a key linked activity with SCI and that there is a need for a mechanism to interphase MBDAV/DB services with evolving scientific consensus from SCI activities.

He gave an update on the NEST Project, which focuses on issues related to skills capability building, knowledge transfer and technical innovation. He mentioned that this new type of joint project is a cross-cutting activity, developed through brainstorming, bilateral discussions and kick-off meetings. He concluded by summarising the key outcomes of the last kick-off meeting held on 11-12 May 2017, where it was decided to draft a final agreement and to identify key players who would later form the core group for the NEST framework.

Regarding staff changes in the NEA, he announced the appointment of Mr. Kenya Suyama as new Head of Data Bank as of spring 2018.

6. Discussion

The future of the WPNCS, proposed new subgroup structure

During the meeting, a proposed subgroup structure was presented and extensively discussed by the participants, which could allow more flexibility and a less formal structure to start new subgroup activities. This proposal is to switch to a subgroup structure like that used in WPEC, towards the WPNCS co-ordinating different technical subgroups with a 2 or 3 year timeframe per subgroup, instead of the historical expert group structure. The technical programme of work for the WPNCS in this proposal is approved beforehand by the WPNCS and executed by the different SGs. Relevant participants from other NEA committees to each SG will add horizontality to the design.

The two technical review groups related to ICSBEP and SFCOMPO databases will keep their current Expert Group structure

There was a general agreement that the main areas of expertise and the scope of activities of the different expert groups will be incorporated into the WPNCS mandate, which will be renewed every three years; the general technical scope of the WPNCS therefore remains identical. The participants also agreed that there should be a plenary presentation where the outcome of the different SG is discussed.

It was agreed that a new mandate of the WPNCS would be drafted by NEA secretariat and sent to the WPNCS members for approval via the written procedure.

7. Reports from the WPNCS Expert Groups

Individual progress of all the WPNCS Expert Groups was presented by their respective Chairs and is summarized below.

Expert Group on Used Nuclear Fuel Criticality (EGUNF)

K. Suyama (JAEA) reported on the progress of activities in the EG. This EG has finished work on Phase I Benchmark *Study on the Reflector Effect of Silicon Dioxide (SiO_2) for the Criticality Safety of Direct Disposal of Used Nuclear Fuel*, which is being edited at the NEA. The EG is currently carrying out work on Phase II Benchmark *Code Comparison for Gadolinium-bearing Fuel Pins in Boiling Water Reactor Assemblies*, which is on-going and its results were presented at this meeting.

Expert Group on Assay Data of Spent Nuclear Fuel (EGADSNF)

I. Gauld (ORNL) reported on the progress of activities in the EG. EGADNSF overlooks the development of the SFCOMPO database. Modernisation of the SFCOMPO database was completed with significant support from NEA Data Bank while data review was supported by external consultants and ORNL: more than 750 samples coming from 44 different reactors of 8 different types are available from the database. Additional dataset from Fukushima-Daini was added to SFCOMPO. In follow-up, SFCOMPO-2.0 has been released and is available on the NEA website www.oecd-nea.org/sfcompo, and by request as an NEA DVD to be distributed by the Data Bank and RSIIC.

The Expert Group approved migrating activities to a new Technical Review Group (TRG) (consistent with ICSBEP structure). The mandate of the new SFCOMPO TRG, based on the former EGADSNF mandate was approved by WPNCS.

Expert Group on Criticality Excursions Analyses (EGCEA)

Y. Yamane reported on behalf of Y. Miyoshi (JAEA) who has stepped down as the chairman of this Expert Group following his retirement. Yamane reported on recent activities on-going within the EG and reported that the final report of this EG is expected to be delivered at the end of 2017.

The EG discussed the new proposal to transition to a subgroup structure and has accepted it. As a result, an extension of the mandate of this Expert Group is not requested, and the Expert Group is formally closed at these meetings. Follow-up activities may be carried out as independent WPNCS subgroups, to be proposed.

Expert Group on Advanced Monte Carlo Techniques (EGAMCT)

E. Dumonteil (IRSN) reported on the progress of activities. The main focus of activity in this EG is preparation of a *Report on Quantifying the Effect of Under Sampling Biases in Monte Carlo Reaction Rates*, which is expected to be delivered at the end of 2017.

Pending completion of the final report the EG Chairman asked for an extension of the EG mandate. Through a written procedure, a 1 year extension was granted for this EG, to be rediscussed at the July 2018 meeting.

Expert Group on Uncertainty Analyses for Criticality Safety Assessments (EGUACSA)

B. Rearden (ORNL) reported on recent activities within the EG, which is currently focusing on completion of two benchmark studies: *Benchmark Phase IV on Correlations between Criticality Safety Benchmark Experiments and Benchmark Phase V on Blind Benchmark on Validation of damp MOX powders calculations*.

The EG discussed the new proposal to transition to a subgroup structure and has accepted it. As a result, an extension of the mandate of this Expert Group is not requested, and the Expert Group is formally closed at these meetings. Follow-up activities, in particular those concerning the continuation of Phase IV and Phase V benchmarks may be carried out as independent WPNCS subgroups, formally to be proposed.

International Criticality Safety Benchmark Evaluation Project (ICSBEP)

M. Marshall (INL) reported on progress made on the ICSBEP database. The technical review group met in October 2017 and reviewed six new evaluations and seven revised evaluations. The *2016 International Handbook of Evaluated Criticality Safety Benchmark Experiments* was published containing 4913 critical and subcritical benchmarks, 45 criticality-alarm/ shielding configurations and 215 configurations with fundamental physics measurements.

After the presentation, it was highlighted that re-evaluation of several benchmarks inputs developed within WPEC would be necessary. It was also proposed that Subgroup 45 should be invited to the next ICSBEP technical review group meeting to re-evaluate certain configurations and benchmarks.

The extension of the mandate of the ICSBEP TRG was proposed and accepted by the WPNCS.

8. Feedback from a UK WPNCS request: Thermal Scattering Data for Ice (H2O)

Following a request made during the past WPNCS meeting, O. Cabellos (Data Bank) presented the impact of low temperature on criticality safety. In his presentation, he outlined IAEA and especially NEA activities on thermal scattering data for ice. The NEA, within JEFF activities, started processing and testing ice water files using Bariloche's CAB model and ENDF/B-VIIIb4 files. He concluded that

NEA activities will be followed by a proposal to adopt Bariloche's CAB model for ice water TSL data as part of JEFF-3.3.

9. Updates on Nuclear Criticality Safety National Programmes

Delegates were requested to submit a written country report providing an overview of criticality safety related programmes or issues to report from their home countries. Country reports aim to:

- Provide convenient formats for disseminating information on national programmes/ incidents/policies.
- Identify items of common interest for consideration by WPNCS as potential collaborative activities within NSC programmes of work.
- Highlight significant changes in national programmes at subsequent meetings.
- Help NEA identify items of common/special interest.

The written reports received are included in Annex A.

10. Date of Next Meeting

The next meeting will be held on 2-6 July 2018. With no other business to discuss, the meeting was adjourned.

11. List of Actions

During the meeting it was agreed that the NEA secretariat will:

- update the mandate of WPNCS, including the scope of activities of the different expert groups;
- update the mandate of the two technical review groups related to SFCOMPO and ICSBEP databases;
- produce a document describing the functions and scope of activities of new subgroup and their review procedure before formal acceptance by the WPNCS.
- All updated mandates will be circulated to the working party members so that they can make comments and/or approve these change through the written procedure.

ANNEX A

Country Reports on Nuclear Criticality Safety National Programmes

1. France

French Context

- The construction of the EPR, the 59th French PWR (GEN-3 - 1.650 MWe), is going on at Flamanville plant ➔ Start-up planned by the end of 2018
- ASTRID, GEN-4-SFR 600MWe industrial demonstrator, under study phase.
- Jules Horowitz Reactor under construction (Research Reactor – 100 MWth) – Operation expected not before 2022
- Start-up experiments, including core qualification tests, of CABRI reactor are completed. First experiment (CIP program) is foreseen in February 2018.
- The assessment of the first periodic safety review of UP2-800 unit (La Hague Reprocessing plant) was launched by IRSN in 2016 at the request of French Safety Authority and should end in the beginning of 2019
- The assessment of the periodic review of the Fuel fabrication facility CERCA (for research reactor) has been launched and should be completed in 2017
- Change of the French Working group on BUC organization and scope of work (enlargement).
- AREVA TN asked for a second transport application (called TN 17 MAX) using BUC with Fission Products for UOX PWR used fuels. Conclusions of the IRSN assessment are expected by October.

R&D Programmes, in particular:

- Qualification tests of CABRI core to be used for MORET5 validation.
- Dosimetry exercise in NNSS with Flat-Top to improve knowledge about consequences of a criticality accident.
- Subcritical experiment using neutron noise techniques (and associated simulations with MORET) in NNSS with the “BeRP ball” and programming of other experiments.
- New Titanium evaluation has been validated on MIRTE experiments and Sandia IE. Results show an significant improvement.
- Signature of the Licence agreement with the NEA for the CRISTAL-V2 criticality-safety package, based on JEFF3.1.1 library and SHEM-281g for the multigroup route. The package should be available at the NEA Databank in the 2nd half of this year.
- The IRSN continuous energy Monte Carlo code MORET 5.D will be proposed for distribution to the NEA.

International Collaborations

- Participation in the ISO working group on NCS (ISO TC85/SC5/WG8 standards). Work on revision of major criticality safety standards (ISO7753 & ISO1709 in particular) and development of new standards (several projects underway).
- IRSN/DOE-NCSP collaboration: following NCSP structure, technical exchanges are based on the five following program elements: Analytical Methods (AM), Information Preservation and Dissemination (IP&D), Integral Experiments (IE), Nuclear Data (ND) and Training and Education (T&E)
- IRSN/JAEA collaboration in the frame of the STACY criticality facility modification and fuel debris experiments with a JAEA staff secondment at IRSN for 12 months.

Future Challenges

- A Criticality Safety Guide, supplementing the Criticality-Safety Resolution of the French Safety Authority, is expected in 2018
- Experimental needs: PIE for fuel assemblies with burnable absorber (Gadolinium) at the reactivity peak, nuclear data at low temperature, etc.
- Organization of the ICNC'2019 in France

2. Slovakia

National Context (Overview)

a. Government Policies:

- the work on final depository was stopped several years ago and from year 2014 has started again, decision about deep geological depository will be around 2030, commissioning after 2065

b. Industry Requirements: -

c. Operating Issues:

- the work on new dry storage (vault system). The international tender for supplier was issued by the begin of year 2017, winner is VUJE (Slovakia)
- the work on a new license for transport cask C-30 for fuel VVER-440 with enrichment 4.87% will start by autumn of year 2017
- a delay in start-up of Unit 3 NPP Mochovce increases

R&D Programmes, in particular:

a. Code development:

- not developed codes
- in Slovakia we use SCALE 6, SCALE 6.1.2, MCNP5, MCNP-X, SCALE 6.2

b. Experiments, Facilities, Skills/Staff requirements:

- inspection stand in ISFSF in Jaslovske Bohunice is in construction, some parts are in operation (gamma spectrometric measurement, TV monitoring)

c. Experimental needs:

- measurement of decay heat of fuel in transport cask is in progress (methodology was already developed, the real measurement will be in future – lack of money)

International Collaborations

a. Ongoing

- IAEA: Technical working group on fuel performance and technology
- OECD/NEA: WP NCS
- AER (Atomic Energy Research): working group "Physical problems of Spent Fuel and Decommissioning"
- the project ALLEGRO – fast gas cooled reactor
- the project ESSANUF - **(**European Supply of SAfe NUclear Fuel), project of European Commission 2015 - 2017

b. Planned: -

Future Challenges

- Urgent need for a new cask for a new fuel with higher enrichment and burnup. Problems by using existing cask and storage facility for a new fuel with higher enrichment and burnup are with

criticality (possible solution is to use BUC), decay heat removal and shielding (possible solution is increasing of cooling time in pool at reactor, it redounds to higher crowdedness of pool at reactor or to decrease number of assemblies in cask).

- A new storage facility: dry storage (vault system), commissioning in 2022.

Input to/from NEA/NSC Programmes of Work

a. Items for discussion at WPNCS: -
b. Items to be discussed in WPNCS Expert Groups: -
c. Items to be forwarded to Nuclear Science Committee: -

3. Spain

National Update

Over the last year, no safety significant event or unusual occurrence has been reported regarding Nuclear Criticality Safety (NCS).

Transportation of high-burnup fuel is currently a licencing issue in Spain. An application has been submitted for high-burnup fuel transportation in a PWR bare fuel cask in which, for the first time, criticality safety analysis of reconfigured fuel have been performed to provide a defense-in-depth support to the cladding integrity methodology selected by the applicant. The licensing process is ongoing.

The licensing process of the Centralized Interim Spent Fuel Storage (ATC) continues. The ATC generic design was approved by the Consejo de Seguridad Nuclear (CSN) in 2006, and is based in a vault system. At the ATC facility the spent fuel and HLW, coming from the plant ISFSIs around the country, will be unloaded from the transportation casks and encapsulated in stainless steel welded canisters specific to the facility. The canisters will be stored vertically in wells cooled by natural draft. The final design of the facility canisters has recently been finished. A bounding NCS analysis for the different fuel designs stored (PWR 17x17, 16x16, 14x14, BWR 8x8, 9x9, 10x10) has been performed, assuming the canister is dry in all operating conditions and the fuel is fresh. Canister flooding has been analysed using BUC, as a Design Extension condition of the facility. A NCS analysis of the ATC Interim Loaded Cask Storage Building has also been performed, including the different transportation casks arriving to the (DPT, HI-STAR 100, ENUN52B…) in bounding storage configurations.

A Spent Fuel and Radioactive Waste Research Laboratory is also projected in the ATC facility to perform studies on spent fuel and other wastes in support of R&D objectives for long term storage and disposal. The laboratory will include a variety of concrete and metallic hot cells of different designs, as well as glove boxes. An NCS analysis of this laboratory is needed, but has not been submitted yet. This laboratory will be open to international collaboration.

R&D

As already reported to EGADSNF at past meetings, a CSN-Enresa collaboration project performed by SEA to evaluate 7 fuel samples from the SFCOMPO database (GU3, DU1, BM5 and GU1 from ARIANE, M11 from REBUS and GGU1 and GGU2 from MALIBU) was performed in the period 2012-2016, and is now finished. It is planned to continue the project with new sample evaluations in a new phase of similar scope and duration.

The main concerns and R&D gaps identified have to do with BWR fuel isotopic data needed to support BUC NCS methodologies for storage and transportation casks. There is lack of experimental isotopic composition data for burnup code validation, and a new measurement project is currently being considered. Analytical work to reproduce the experimental results of other samples continues.

International Collaborations

Participation in NEA working/expert groups:
- NSC/WPNCS Expert Groups (EGADSNF, EGBUC)
- CSNI Working Group on Fuel Cycle Safety (WGFCS).

Future Challenges

In the near future, new applications for BWR SNF casks criticality safety methodologies taking credit from gadolinium and/or fuel burnup are expected. There is no previous national experience on this issue regarding dry storage/transportation casks.

Adequate fuel classification as damaged/undamaged prior to cask loading is the basis to perform conservative criticality safety analysis. A number of authorized storage and transportation casks, with no damaged fuel as approved contents in their licensing basis, will need certificate amendments to implement this option. Classification issues for BWR fuel and safety analysis scope to demonstrate criticality safety in any eventuality are expected.

HBF transportation issue will probably require new applications assessing the impact of fuel reconfiguration due to fuel failure on the criticality safety analysis of used nuclear fuel in transportation casks.

The review of the criticality safety demonstration of the Centralized Interim Spent Fuel Storage (ATC) will be shortly undertaken, also as a new licensing challenge because of two reasons. In the first place, it will be the first time that Design Extension conditions for the facility will be directly included in the licensing basis. In addition, the initial licensing period requested is 60 years, but the design basis is 100 years. As a result, degradation phenomena potentially affecting NCS of the SNF storage will need to be identified and addressed.

Input to/from NEA/NSC Programmes of Work

a. Items for discussion at WPNCS.
b. Items to be discussed in WPNCS Expert Groups
c. Items to be forwarded to Nuclear Science Committee

4. Swiss

National Context (Overview)

No news.

R&D Programmes

Two major activities in relation to the NCS and BUC applications have been conducted at PSI since the previous WPNCS meeting: 1) Finalization of the joint PSI/NAGRA R&D project BUCSS-R on derivation of preliminary loading curves for Swiss PWR SNF final repository and 2) Continuation

of works on upgrading PSI CSE methodology, partly as the result of the experience gained with participation in the UACSA EG (see the presentation given at the UACSA EG meeting).

Two R&D projects on characterization of spent fuel and quantification of associated uncertainties have been ongoing at PSI since 2016 in cooperation with swiss*nuclear* association, as was already reported at the previous WPNCS meeting. For validation studies, new dedicated neutron and gamma flux scanning measurements are planned to be done at PSI's Hotlab by the end of 2017. For calibration purposes, well characterized spent fuel samples previously analyzed by destructive analyses within the past LWR-PROTEUS experimental program at PSI will be used. In the frame of the above PSI/swiss*nuclear* R&D projects, validation and UQ studies of the fuel depletion and decay simulations are being continued using set of codes (CASMO, MCNP, Serpent, etc.) and mainly based on proprietary PIE data available at PSI. The Studsvik code SNF working in combination with the CASMO/SIMULATE codes family is in use at PSI since 2016 for consistent SNF compositions predictions and validations of CASMO/SIMULATE models with Swiss reactor measurements. In addition to that, substantial work on the nuclear data uncertainties propagation through CASMO/SIMULATE/SNF calculation sequence for decay heat, activity and radiation source assessments has been performed showing noticeable contribution of the nuclear data to the overall calculation uncertainties of the SNF characteristics.

Additionally, Nagra carried out a study to evaluate the criticality safety and shielding assessment for a set of candidate disposal canister concepts considered for the final disposal of BWR and PWR SNF.

The Nagra experimental program, initiated together with the EPFL and the JRC Karlsruhe, European Commission, on spent fuel integrity during interim storage is currently on going. Impact tests and loading tests on real SF rods are conducted in the hot cell facilities of JRC Karlsruhe. The impact tests performed on individual rods are showing that no defueling or large fuel release took place, being the fuel release limited to the affected area (less than one pellet). This would serve as experimental bounding case for criticality safety assessment in the licensing process of the T/S SF casks.

International Collaborations

- PSI continues participation in OECD WPRS activities including UAM benchmark and C5G7-TD benchmark.

- In the context of joint OECD/NEA WGAMA-WGFS activity, PSI has participated in 2016-2017 in evaluation of Phenomena Identification and Ranking Table (PIRT) on Spent-Fuel Pools in Loss-of-Cooling/Coolant Accident Conditions, which included criticality assessment.

- PSI staff participates in the JEFF project of the OECD/NEA Data Bank and contributes to the JEFF and ENDF/B-VIII libraries next releases preparation and validation assessment. For instance, PSI results of JEFF3.3 validation with MCNPX modeling of ICSBEP benchmark cases were presented at the JEFF working group and later at the ND2016 conference.

- With respect to the Nuclear Data related developments, a study on correlations between nu-bar, chi and cross sections was performed together with CEA Bruyeres-le-Chatel. An evaluation of the impact of such correlation matrices on simple criticality systems has been performed as well.

- PSI and NAGRA has participated in the Long Term Criticality Workshop, held in Stockholm in April 2017 and organized jointly by SKB and NAGRA. Progress and challenges in development of the final geological repository concepts in several European countries including Switzerland, particularly related to the criticality safety aspects, were discussed at the workshop.

- The TENDL library is presently hosted at PSI and the recent progress in its continuous development has been reported at the ND2016 conference.

Future Challenges

A follow-up of the Nagra/PSI collaboration on the recently finished BUCCS-R research project is under preparation. New studies will be performed using latest information on the accidental scenarios developed by NAGRA, in particular for degraded configurations, such as may occur in the long term in the repository after extensive corrosion and structural degradation of the canister and fuel assemblies. As well, the project will include refining of the so far obtained preliminary PWR BUC loading curves with improved UQ based on the latest progress in the methodology developments achieved at PSI.

Input to/from NEA/NSC Programs of Work

No news comparing to the past years

5. United Kingdom

National Context (Overview)

a. Government Policies (related to issues discussed)

The UK Government provides central regulation of the UK nuclear industry via its Office of Nuclear Regulation (ONR), who regulate day-to-day operations, and its various environment agencies, who regulate waste disposals.

In 2016, the UK ONR took a “fresh look” at the criticality safety rules set out in the IAEA transport regulations (SSR-6). From this, ONR have tasked UK transport package licensees to produce more detailed evaluations of the effects of temperature on k-effective. UK industry bodies have been collaborating, so that they can deal with these requests in a co-ordinated fashion. Internationally, ONR have also been sharing their position on these issues with other regulators. Given the IAEA requirements for the multilateral approval of fissile transport safety cases, it is expected that the UK will be working with other countries, to achieve an international consensus on the interpretation of these regulations.

ONR has recently issued a position statement regarding the consideration of temperature on nuclear criticality safety in transport applications (http://www.onr.org.uk/transport/index.htm). In addition, it has published an ONR technical assessment guide (TAG) on the criticality safety assessment of transport packages; this includes a section on temperature (http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-097.pdf).

The UK Government also funds the central co-ordination and management of nuclear legacies, via the Nuclear Decommissioning Authority (NDA) and Radioactive Waste Management Limited (RWM).
Most of the operations in the rest of the UK industry are now either privatised (e.g. in the case of civil nuclear fuel manufacture and power stations) or contracted out, to consortia employed by the NDA to manage former BNFL and UKAEA nuclear sites.
From this background, the UK government owned National Nuclear Laboratory (NNL) does now receive some limited government funding, to assist with issues that are (or will be) of strategic importance to the future of the UK nuclear industry.
In 2016, the UK Government approved the EDF project to build a new nuclear power station at Hinkley Point in the UK.
https://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c
This is a very significant milestone for the UK industry. As the initial construction work proceeds, work will also process on the station's criticality safety case.
Also in the UK, there are other proposals and plans to build further new nuclear power capacity (€70 billion), at seven other sites around the UK: Sellafield, Sizewell, Oldbury, Wylfa, Bradwell, Heysham and Hartlepool.

b. Industry Requirements (skills capability, training, etc.)

Shortages of qualified criticality engineers are a recognised problem in the UK industry.

- A number of UK universities provide good basic academic courses that support the industry;
- Most UK companies provide dedicated training for their staff;
- It is good to see the USA opening its "hands-on" courses to delegates from other countries, and to see UK delegates on those courses.

In spite of the above measures, it can take 4 or 5 years to fully train new entrants to the field of nuclear criticality safety.

c. Operating Issues (e.g: unusual occurrences to report)

Nothing to report

R&D Programmes, in particular:

a. Code development

RWM have been sponsoring the development of post-closure criticality consequences codes, to answer "what-if" questions relating to the potential local effects of a criticality excursion on the multiple engineered barriers that comprise a geological disposal facility. This approach is required to satisfy UK regulatory requirements; applications for waste disposal permits require safety cases to show that the risks of criticality accidents have been minimised and any potential consequences of criticality to be assessed. Much of the work carried out by RWM is subsequently published via the NDA website (see http://www.nda.gov.uk/publications/).
Commercial code developments are also carried out by the ANSWERS team within AMEC Foster Wheeler. Some of the details are commercially sensitive and are not reported in detail here. However, ANSWERS have submitted a number of papers to recent conferences and these provide a good overview of their latest work. From the recent 2017 ANSWERS Seminar a few highlights of recent or current UK work are:

- As part of the UK response to the latest ONR position on SSR-6, ANSWERS are developing MONK nuclear data files that will give a wider range of tabulated S(α, β) data, including some for the modelling of "low temperatures" (i.e. sub-room-temperature values).
- ANSWERS have been working for several years to incorporate nuclear data "covariance matrices" into tools for prior predictions of code uncertainties. A 2017 Seminar presentation demonstrated a reasonable degree of agreement between results from these tools and traditional methods of code validation.

b. Experiments, Facilities, Skills/Staff requirements

There are currently no experimental criticality facilities in the UK.

c. Experimental needs

The recent interest of ONR Transport in more explicit criticality safety assessments for the full operating range of transport package operating conditions may lead to requirements for validation experiments at temperatures below room temperature. As these needs originate from the IAEA Transport Regulations, it seems most likely that the UK would seek to collaborate with the operators of (international) experimental facilities, to see if suitable experiments can be conducted.

International Collaborations

a. Ongoing

The British Standards Institute provides limited funding for UK involvement in the production of ISO standards. On their behalf, NNL leads this work, including that on the development of new ISO standards for (i) fissile waste management and (ii) criticality training for plant operators. These efforts are being carried out in consultation with the UK Working Party on Criticality (WPC). The WPC is a national non-executive body that seeks to bring together UK regulators and industry to share best practices in criticality safety management.

b. Planned

Nothing to report

Future Challenges

Nothing to report

Input to/from NEA/NSC Programmes of Work

a. Items for discussion at WPNCS.

i) Whilst IAEA co-ordinates the international regulation of transport packages, it would be useful to hear the view of WPNCS members on:

- The importance of modelling the full range of temperatures that may be required for compliance with SSR-6;
- Where the state-of-the-art lies in terms of good codes and data for this;
- The potential role of future international collaborations for improving the state-of-the-art here.

ii) Recent events in the USA and Russia (and the dissemination of information about them) pose the question as to whether or not the WPNCS could do more to cover topics such as the sharing learning from experience about causes and circumstances of criticality accidents (and "near misses") and/or the promotion of good practices for their prevention.

b. Items to be discussed in WPNCS Expert Groups

None

c. Items to be forwarded to Nuclear Science Committee

None

6. United States

National Context

The United States has fissile material operations involving all portions of the nuclear fuel cycle. Research in the area of advanced reactor concepts continues to investigate use of fuel with >5wt% enrichments, in the area of industrial and government activities the focus is on production and fabrication of reactor fuel with enrichments <5wt%, and a growing interest in metallic fueled fast reactors, liquid fueled molten salt reactors, fluoride salt-cooled high temperature reactors, and high temperature gas reactors. As the industry grows and develops, many criticality safety issues on the front end and back end of the fuel cycle will need to be addressed. Delays in the MOX fuel fabrication plant (caused by funding and design/construction challenges) have limited the need for attention to criticality safety issues involving transport or storage of MOX fuel.

The current fiscal year 2018 budget request includes substantial funding to restart studies for the spent fuel repository site at Yucca Mountain, with indications from congress that this initiative will be supported. In the past year, the NRC received an application for a Consolidated Interim Storage Facility (CISF) in Andrews County, Texas from Waste Control Specialist. Staff performed acceptance reviews and issued a number of Request for Supplemental Information (RSI). The applicant responded to most RSIs. However, the applicant has requested the review to be placed on hold. The NRC received a second application for an interim storage facility from Holtec International in March of 2017. The application is currently under acceptance review. Final repository options and overall storage, transport, and disposal systems are being studied by DOE to provide the technical information for future decisions regarding the back end of the fuel cycle.

The DOE, including its autonomous National Nuclear Security Administration (NNSA), and the NRC each have responsibility for providing regulatory oversight on criticality safety – DOE for operations within the DOE complex and NRC for industry operations. The American Nuclear Society (ANS) is the US professional organization that works to develop consensus standards for criticality safety and organize technical meetings on criticality safety. Each of these organizations develops, sponsors, or supports training classes and workshops to support education and knowledge exchange in the field of criticality safety. The number of universities offering classes and degree certificates focused on criticality safety has risen over the last few years.

R&D Programmes

The DOE and NRC both support research activities in the area of nuclear criticality safety. The DOE Nuclear Criticality Safety Program (NCSP) has provided a central focus for research and

technology development for over 15 years. The DOE NCSP (see http://ncsp.llnl.gov/) has five elements: Integral Experiments, Analytical Methods, Nuclear Data, Information Preservation and Dissemination, and Training and Education. Integral experiments (and hands-on training classes) are conducted at the Nuclear Criticality Experiments Research Center (NCERC) and at Sandia National Laboratories (SNL). Experiments at NCERC are conducted by Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL).

All four critical experiment machines at NCERC (Planet, Godiva, Comet, and Flattop) are available, and the facility operates as a user facility to help meet national and international program needs. Operations with the Godiva pulse reactor were restarted in Dec. 2015.

The NCSP has conducted "hands-on" critical experiment training classes at NCERC during the past year. Specifically, the NCSP conducted three 2-week training class for NCS practitioners since February 2016. The 2-week classes include one week of classroom training at the Nevada Field Office in Las Vegas, NV, followed by one week of hands-on critical experiment training at either SNL or NCERC. In addition, the NCSP conducted 1-week hands-on critical experiment training classes for regulators, managers, and operations professionals who need to understand the fundamentals of nuclear criticality safety. A 1-week manager's course was conducted at SNL in January 2017 and at NCERC in June 2017. Since establishing the NCSP hands-on training courses in 2011, over 250 students have taken the NCS hands-on training course.

With regard to information preservation and dissemination, the NCSP in collaboration with CEA completed the benchmark evaluation of the second and third of three pulsed SILENE experiments that were performed in 2010. The benchmark evaluations were published in the 2016 edition of the ICSBEP Handbook. The first experiment was previously published in the 2015 edition of the Handbook. In addition, the NCSP completed the LEU-COMP-THERM-097 benchmark for Ti/Al rods in a UO_2 Lattice array, and this evaluation was published in the 2016 edition of the ICSBEP Handbook. A revision was issued for the nickel reflected plutonium ball evaluation that was first published in 2015. A new evaluation was published for the tungsten reflected plutonium sphere subcritical measurements.

Integral experiment research over the last year has included: a nuclear accident dosimetry exercise using Godiva, the final design of the TEX-Hafnium experiments, design work for experiments on the plutonium sphere at NCERC using composite CH_2/Ni reflector, validation of analytical methods with MC-15 measurements, the performance of the Subcritical Copper-Reflected α-phase Plutonium (SCRαP) experiments, development of neutron multiplication measurement protocol, work on the Kilowatt Reactor Using Stirling Technology (KRUSTY) experiments, work with the Flattop experiment assembly at NCERC, design of experiments to study the critical effects of plutonium aging, and design of titanium sleeve experiments in the BUCCX reactor at Sandia.

With regard to Analytical Methods, MCNP and SCALE are key codes used for criticality safety within the DOE complex and are supported by the NCSP, with nuclear data libraries generated by NJOY and AMPX. A key area of development has been sensitivity/uncertainty methods using continuous energy data and investigating advanced validation methods. The multi-laboratory Nuclear Data Advisory Group (NDAG) prioritizes nuclear data measurements and evaluations supported by the NCSP and coordinates NCSP activities with the US National Nuclear Data Center to assure inclusion in the Evaluated Nuclear Data Files (ENDF). Funding to help support processing of ENDF data for the criticality safety codes is also provided by the NCSP and production ENDF/B-VII.1 libraries with expanded cross section covariance data are available for the key NCS analyses code packages. The ENDF/B-VIII library is in beta release with many new features including

expanded thermal scattering data for reactor grade graphite and pyrolytic carbon needed for advanced reactors as well as water in ice form to temperatures below -40°C as requested by International Atomic Energy Agency transportation guidelines.

The SCALE and MCNP teams both provided training classes to US and international participants. SCALE offers two weeks of training classes on criticality safety and uncertainty analysis methods at the OECD NEA as well as a week of training on spent fuel characterization at the National Research Nuclear University MEPhI (https://eng.mephi.ru) under NEA sponsorship. The MCNP and SCALE codes continue to be highly regarded Monte Carlo codes. SCALE is one of the most highly requested codes from the NEA Data Bank, with distributions to over 2000 Data Bank members over the past decade.

In the Nuclear Data program element, prioritized nuclear data measurements and evaluations continue to be performed to support NCS operations in the US. During the past year, new differential measurements have been performed on natural V and Zr samples. Also, substantial progress has been made to expand the RPI linear accelerator neutron capture measurement capabilities into the keV range that is important for many nuclei pertinent to criticality safety. Furthermore, the NCSP has partnered with NNSA Naval Reactors to invest in an accelerator refurbishment effort at RPI to ensure the US has a differential data measurement capability for performing needed cross-section measurements. With regard to new cross-section evaluation work, the NCSP has completed new resonance region evaluations for ^{63,65}Cu, ^{56}Fe, ^{16}O, and ^{182,183,184,186}W. These new evaluations are undergoing testing and are expected to be available with the next release of the ENDF data library. A new initiative known as the Interagency Nuclear Data Working Group recently coordinated multi-faceted funding opportunity announcement for new nuclear data evaluations to support a number of priority programmatic needs for the DOE Office of Nuclear Physics, Isotope Program, Office of Nuclear Energy, NNSA/Defense Nuclear Nonproliferation Research and Development, Department of Homeland Security, and Domestic Nuclear Detection Office. It is hoped that substantial new initiatives will provided many updated nuclear data evaluations with high quality uncertainties will become available to the community.

NRC continues its support for research focused on use of Burnup Credit in designing criticality control systems for BWR spent fuel storage casks and transportation packages. The first phase of research which was focused on BWR peak reactivity was completed by issuing a NUREG report. The second phase of the research, which is examining beyond peak reactivity, is currently underway and is planned to be completed next year. BWR research is being driven primarily by loss of geometry concerns of storing high burnup fuels and the planned extension of fuel storage time limits beyond 20 years.

International Collaborations

The NNSA continues to interact with AWE in the UK and CEA and IRSN in France to identify and collaborate on nuclear criticality safety issues of mutual interest, such as integral experiments, computational methods, and improved nuclear data. During the past year, the collaborations have resulted in personnel from the US performing collaborative work at IRSN, CEA, and AWE. Likewise personnel from AWE and IRSN have visited the US to perform collaborative work tasks at NCSP sites. Within the DOE NCSP, ORNL and IRMM collaborate to perform neutron cross-section measurements in the resonance region to address differential data needs identified as important to improvement of nuclear criticality safety analyses.

Under OECD/NEA WPEC, US National Laboratories are working with other international partners on the CIELO (Collaborative International Evaluated Library Organization) to improve nuclear evaluations, many of which support improved evaluations for nuclear criticality safety. Specifically, the CIELO collaboration has focused efforts on completing new evaluations for ^{235}U, ^{238}U, ^{239}Pu, ^{56}Fe, and ^{16}O.

In addition, the NCSP provides support for the US participation in the ICSBEP. Additionally, the DOE Office of Nuclear Energy Advanced Modeling and Simulation (NEAMS) program provides support for the US leadership of the ICSBEP.

Future Challenges

Organizations face a continuing challenge to maintain a fully compliant criticality safety program with qualified personnel experienced in both the principles of criticality safety and the fissile material operations, with the need for planning to support the needs of the advanced reactor community. In addition, a challenge is related to succession planning for key staff expertise needed to support NCS. To meet this challenge, the NCSP is continuing to invest in succession planning for key NCS technology capabilities that include specialists in integral experiments, nuclear data, and analytical methods.

Holdup residues can contribute significantly to the inventory of nuclear material within process equipment and, at any time, can represent the largest portion of inventory uncertainty. As such, these residues can challenge assumptions and limits needed for nuclear criticality safety. The NNSA has initiated work to establish a safety-related *in situ* nondestructive assay (NDA) program to manage and direct research and development (R&D) tasks needed to improve NDA capabilities for quantifying nuclear material holdup. A mission and vision document for the NDA technology program is in development and should be published in the coming year.

Input to/from NEA NSC Programmes of Work

The U.S. continues to engage in each of the Expert Groups of the Working Party on Nuclear Criticality Safety as well as in other NEA working parties. US participants are actively engaged or are leading activities within the Nuclear Science Committee WPNCS. The US leadership is provided for the WPNCS Expert Group and Assay Data for Spent Nuclear Fuel, with the SFCOMPO-2.0 release occurring during this meeting. US leadership is also provided for the Expert Group on Uncertainty Analysis for Criticality Safety Assessment. Involvement in other NSC activities include: Working Party on International Nuclear Data Evaluation Co-operation (WPEC), Working Party on Reactor Systems (WPRS), Expert Group on Improvement of Integral Experiments Data for Minor Actinide Management (EGIEMAM-II), Expert Group on Accident Tolerant Fuels for Light Water Reactors (EGATFL), The Working Party on Scientific Issues of the Fuel Cycle (WPFC), Expert Group on Multi-physics Experimental Data, Benchmarks and Validation (EGMPEBV), and WPEC Subgroups: 44 on Investigation of Covariance Data in General Purpose Nuclear Data Libraries, 45 on Validation of Nuclear Data Libraries (VaNDaL) Project, and 46 on Efficient and Effective Use of Integral Experiments for Nuclear Data Validation. Additionally, the US engages with the activities of Committee on the Safety of Nuclear Installations (CSNI) not listed here. These engagements are sponsored by numerous agencies, but the DOE/NNSA or NRC are the primary sponsor of the participants and their contributions.

ANNEX B

21st Meeting of the Working Party on Nuclear Criticality Safety (WPNCS)

AGENDA

Proposed Meeting Schedule: ***9h00 – 17h00***

1.	Welcome	*Chair*
2.	Administrative	*Secretariat/All*
	• Approval of the agenda	
	• Approval of the summary record from the previous meeting	
	• Review of Actions from the previous meetings	
3.	Transition of WPNCS chairmanship	*Secretariat*
4.	Feedback from the Nuclear Science Committee Meeting	*T. Ivanova*
5.	Discussion	
	• The future of the WPNCS, proposed new sub group structure	*F. Michel-Sendis*
6.	Reports from the WPNCS Expert Groups and extension of mandates	
	• Advanced Monte Carlo Techniques Expert Group (EGAMCT)	*E. Dumonteil*
	• Assay Data for Spent Nuclear Fuel Expert Group (EGADSNF)	*I. Gauld*
	• Criticality Excursions Analyses Expert Group (EGCEA)	*(TBD)*
	• Uncertainty Analyses for Criticality Safety Assessment (EGUACSA)	*B. Rearden*
	• Used Nuclear Fuel Criticality (EGUNF)	*K. Suyama*
	• International Criticality Safety Benchmark Evaluation Project (ICSBEP)	*M. Marshall*
6.	Feedback from a UK WPNCS request: thermal scattering data for ice (H2O)	*O. Cabellos*
7.	Updates on Nuclear Criticality Safety National Programmes	*All*
8.	Any other business	*Chair*
9.	Date and place of the next meeting	*Secretariat*
10.	Adjourn	*Chair*

ANNEX C

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