ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT
Nuclear Energy Agency
Nuclear Science Committee
Working Party on Nuclear Criticality Safety

THE EIGHTEENTH MEETING OF THE WORKING PARTY ON NUCLEAR CRITICALITY SAFETY

Friday September 19, 2014

NEA Headquarters, Issy-les-Moulineaux, France

SUMMARY RECORD

The Working Party on Nuclear Criticality Safety (WPNCS), and its five associated Expert Groups met during the week of September 15-19, 2014 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 Technicques (EGAMCT)

1. Introduction & Welcome

The WPNCS chair, **Ms. Michaele Brady-Raap** (USA) presided over the meeting.

Brady-Raap opened the meeting and welcomed the participants who briefly introduced themselves. 74 people registered to the week-long meetings (see participant list in annex B).

2. Review of actions from previous meeting

There were no outstanding actions to review.

3. Approval of the summary records and agenda

The summary records of the past meeting were approved with editorial modifications and inclusion of past country reports that had been submitted.

4. Nuclear Criticality Safety National Programmes

Before the meeting, delegates are kindly requested to submit a written country report providing an overview of criticality safety related programmes or issues to report from their home countries. National Activities Reports at Working Party meetings 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 reports received in written form are included in Annex A.

5. Reports from the WPNCS Expert Groups

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

Expert Group on Burn-up Credit (EGBUC)

Brady-Raap reported on progress on the EG. The Expert Group on Burn-up Credit has formally closed down after more than twenty years of existence. Progress on its final deliverables is as follows:

- Phase VIII benchmark (on reactivity worth calculations/analysis of small-sample reactivity experiments) is completed. The final report is expected to be submitted to NEA in 2015 (next WPNCS meetings);
- Report on Phase IIIC benchmark on Nuclide Composition and Neutron Multiplication Factor of BWR Spent Fuel for Burn-up Credit and Criticality Control of Damaged Nuclear Fuel has been submitted to NEA and is pending publication.
- Final Phase II-E report on the Impact of Changes in the Isotopic Inventory due to Control Rod Insertions in PWR UO2 Fuel Assemblies is completed and submitted for publication at NEA.
- A Handbook on PWR Burn-up Credit methodologies as applied to PWRs has been compiled. This Handbook will be the final deliverable of the EG, expected for publication in 2015.

Proposal for a New Expert Group on Used Nuclear Fuel (EGUNF)

As a follow-up Expert Group to the now closed EGBUC, a draft proposal for a new mandate for an Expert Group with a larger scope has been circulated internally and discussed by key participants. The proposed new Expert Group has already defined a first activity, which is distributed for discussion. The participants elect Mr. Kenya Suyama (JAEA) as chairman of this new Expert Group, pending formal approval by the NSC.

The proposed new scope of this EG is:

"The Expert Group will perform specific tasks associated with the scientific issues of assessing criticality safety for systems and operations involving used nuclear fuel (UNF). The development and evaluation of calculational methods to predict UNF isotopic composition and their impact on reactivity (i.e. the application of Burnup Credit); modeling of static and transient conditions in UNF operations; and the evaluation and management of damaged UNF are included in the Scope of this Expert Group. The types of fuel facility and operations covered include; fabrication, transportation, storage, reprocessing, waste management and disposal. The Expert Group will consider a wide range of fuel types, including UOX and MOX fuels for PWR, BWR and VVER."

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

After significant changes, the Guidance Report on the Evaluation of Assay Data has undergone another revision by the Expert Group and is nearing finalization. The report is expected to be published in 2015.

The SFCOMPO 2.0 application has been developed in 2013-2014 by the Data Bank. The new SFCOMPO database more than doubles the amount of assay data sets as compared to the first version. An internal review process of the data that is imported in the new SFCOMPO application is ongoing, with volunteer reviewers from the EGADNSF. This review is expected to be completed in 2015. Plans to distribute the new SFCOMPO through the DB and RSICC when released have been discussed. Further development of the tool (improved functionalities) is expected after release with support from NEA Data Bank.

During the meeting participants made clear it was a priority to release SFCOMPO-2.0 after sufficient verification of the data was achieved.

Expert Group on Criticality Excursions (EGCEA)

Miyoshi reported on progress in the EGCAE which covers the update on the status of the report for Phase II and the specification of Phase III. Drafting of the report for Phase II, which is based on solution experiments at the TRACY facility in Japan, will commence early in 2015, following submission of the final results in October 2014. Participants are planning to submit results for Phase III (long-duration solution criticality event) during 2015.
Future activities include plans for studies on a criticality excursion in plutonium nitrate solutions with positive temperature (including thermal expansion) coefficients. Several participants noted the need for improved treatment of bubbling and sloshing for long-duration events.

Expert Group on Uncertainty Analyses for Criticality Safety Assessment (EGUACSA)
Ivanova reported on progress on the EG.

- The first part of the State-of-the-art report has been published.
- The report on Phase III is expected to be finalized in 2015.
- Phase IV Benchmark on *establishment of correlations in experimental uncertainties* is ongoing.

Tatiana Ivanova will join the NEA in November 2014 to work in the Nuclerar Science Division. In anticipation of her functions as NEA staff, she announced her stepping down of her position of Chair of the EGUACSA group. The Expert Group selected Brad Rearden (ORNL) who has accepted to take over as chairman of the group.

Expert Group on Advanced Monte Carlo Methods (EGAMCT)

Miss reported on the ongoing progress on the study of the EGAMCT phase I benchmark on *Quantifying the Effect of Under-sampling Biases in Monte Carlo Reaction Rate Tallies.* The meeting had very good participation were reviewed. Completion of Phase I benchmark is expected by next meeting, in 2015.

International Criticality Safety Benchmark Evaluation Project

Bess reported on the annual *Technical Review Group for the International Criticality Safety Benchmarks Evaluation Project* meeting held in Paris in May 2014, and went through new expected additions to the 2014 Handbook, expected for release in October 2014.

Any Other Business and Date of Next Meeting
With no other business to discuss, the meeting was adjourned.

List of Actions

1. Action on all delegates - To confirm with NEA the name of official representatives of each member country to the WPNCS

2. Action on all delegates- To submit to NEA if not already done the written National Report for inclusion in the minutes.

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ANNEX A

Country Reports on Nuclear Criticality Safety National Programmes

1. Czech Republic (Markova)

CEZ Company, the owner of the Czech NPPs, canceled the tendering process for building of two new units of the Temelin NPP (2x1000 MW up to now). The official reason was that nowadays revenues of investments belonging to energy industry are highly risky without a government participation. The participation was asked by CEZ but such a practice is not accepted by EU.

1.1. R&D Programmes

In compliance with trying of EURATOM to initiate research focused on safety aspects of loading western nuclear fuel assemblies in VVER (Work Programme NERP-16), R&D project on analysis of PIE data acquired for Westinghouse spent fuel used in the Czech Temelin NPP (originally VVER-1000) was submitted to the CEZ Company, the owner of Temelin. The project is intended to support that one just being prepared in ORNL on PIE including samples of various fuel.

1.2. International Collaboration

New benchmark "VVER-1000 Mock-up Physics Experiments Hexagonal Lattices (pitch of 1.275 cm) of Low Enriched UO_2 Fuel Assemblies (2.0, 3.0, 3.3 wt.% U235) in Light Water with H_3BO_3" was evaluated in Research Center at Řež and is prepared to be included into 2014 IRPhEP Handbook NEA/NSC/DOC(2006)1 under ID number LR(0)-VVER-RESR-002, CRIT-COEF-RRATE. Six critical experiments on radially full scale core segment with VVER-1000 type boundary are included into the benchmark.
The experiments focused on finding reaction rates and space distribution of fast energy neutron flux will be evaluated as the next work phases.

1.3. Future Challenges

A new project on spent fuel disposal in the Czech Republic related to spent fuel cask design and several other repository issues supported by RAWRA (the Czech Radioactive Waste Repository Authority) started in XI/2013 and will continue until 2018.

2. France (Letang)

2.1. National context in France

- French government announce: nuclear electricity production decreases from 80% to 50% in 2025.
- Build-up of the EPR reactor is going on at Flammanville. The coupling to electric network is planned for the end of 2016.
- Fessenheim reactor is planned to be closed at the end of 2016.
- IRSN Technical Support to ASN French safety authority for writing the new French Regulation about NCS (ASN criticality decision) expected for the end of the year after several months of public consultation. This "criticality decision" and an associated guidance (expected a few years later) are devoted to replace the Basic Safety Rule (RFS) n°I.3.c (1984).

- Safety review of UP3 unit (La Hague Reprocessing plant) by the standing advisory group, last advisory group for the beginning of 2015.
- Safety review for the definitive stop and the dismantling of the PHENIX reactor by the standing advisory group.
- Safety review of FBFC plant (UOx fuel Fabrication) by the standing advisory group at the end of 2014.
- Licensing for the creation of two new Nuclear facilities: DIADEM (waste storage facility at Marcoule) and ATLAS (U laboratory at Tricastin).

Several level 1 incidents affecting waste drums for which the recent measures lead to fissile masses of fuel clearly superior to the historic values.

2.2. R&D programmes

<u>Code development</u>

- Verification and experimental validation of the CRISTAL V2.0 criticality package for the APOLLO-MORET route – CRISTAL Package planned to be available at OECD databank at the end of 2014.
- MORET code: delivery of the 5.B.2 version of the MORET code at OECD databank planned at beginning of 2015.
- New Version is in progress with the following points: implementation of probability tables, alternative methods for perturbation calculations (based on Taylor series), calculation of keff sensitivity to neutron cross sections (benchmarking with SCALE planned in a framework of ORNL/IRSN collaboration).
- VESTA code status (generic Monte-Carlo depletion system): VESTA v2.1 experimental validation with the use of 42 samples with radiochemical analysis and 34 samples with decay heat measurements. Fuel samples are representatives of current PWR spent fuel (UO2, MOX, UO2-Gd2O3), the burn-up range extends from 7 GWj/t up to 67 GWj/t. The qualification reports dealing with open experimental data are available on demand at IRSN.

<u>Experiments, facilities</u>

- December 2013: end of the MIRTE program (MIRTE for " a criticality experimental program for the validation of structural materials") in December 2013 in the Apparatus B of the Valduc facility. Last experiments in the APPARATUS B facility

with UO2 rods lattice in sodium chloride solution. After SILENE in 2011, the Apparatus facility is closed.
- June and September 2014: CALIBAN/PROSPERO experimental programm for the test of radiation detectors and CAAS performance to detect “small” critical events. These experiments have been performed within the CEA/CALIBAN reactor in partnership with LLNL (DOE), AWE (UK), operators (AREVA) and detectors providers.

2.3. International collaboration

- Participation in the UK criticality Course at Sellafield as teaching staff.
- Participation in the ISO working group on NCS (ISO TC85/SC5/WG8 standards). Next meeting will be held at IRSN (27 – 28 October 2014).
- Participation in the IAEA Workshop on Criticality Safety in the Handling of Fissile Material for Fuel Cycle Facilities in Vienna (24-28 February 2014) as chairman.
- New IRSN project: PRINCESS project (Project for IRSN Neutron Physics and Criticality Experimental data Supporting Safety) whose the objective is the acquisition of experimental data in the field of criticality safety and reactor physics, based on IRSN needs analysis
- Feedback from criticality and reactor safety assessment,
- State-of-the-art in R&D.
- The acquisition can be made from finished, on-going or future programs with international partners from US (DOE laboratories in the framework of the NCSP), Japan, Russia, Europe (France/CEA, Belgium/SCK-CEN, etc).

Participation in NEA Activities

- Participation in the ICSBEP Meeting: one evaluation MIX-MISC-THERM 007 (Arrays of UO2-PuO2 PHENIX pins containing 26% of plutonium (240Pu/Put=16%) in a plutonium nitrate solution).
- Participation in WPNCS Expert Group on Advanced Monte Carlo Techniques (EGAMCT), WPNCS Expert Group on Burn-up Credit Criticality Safety (BUC), WPNCS Expert Group on Uncertainty Analysis for Criticality Safety Assessment (UACSA), WPRS Expert Group on Uncertainty Analysis in Modelling (EGUAM), WPRS International Reactor Physics Benchmark Experiments (IRPhE) Project, WPEC SG Methods and issues for the combined use of integral experiments and covariance data (SG33), WPEC SG Beyond the ENDF format: A modern nuclear database structure (SG38), WPEC SG Methods and approaches to provide feedback from nuclear and covariance data adjustment for improvement of nuclear data files (SG39), WPEC SG Collaborative International Evaluated Library Organization (SG40 CIELO).

3. Germany (Kilger, Tittelbach, Hoefer)

3.1. National Context

- NPP Grafenrheinfeld applied for disconnection from the grid and final shutdown for spring 2015, following the 2002/2011 phase out decision.

- Repository Site Selection Act ("StandAG") to coordinate the search for a site for heat generating waste is currently under review of the "commission responsible for preparing the selection procedure" ("repository committee").
- "Federal Office for the Regulation of Nuclear Waste Management" commenced operation September 1, 2014.
- Graphite fuel elements from AVR high temperature test reactor in interim storage at Research Center Juelich: Storage has to be ended September 30, 2014; no final decision about repatriation or transport to central storage facility Ahaus yet.
- Licence (1996 IAEA regulation) for BWR SNF transport and storage cask CASTOR® V/52 granted in September 2014.
- Recent DIN standard updates/reviews
- DIN 25403-7:1996-08 "Criticality safety in processing and handling fissile materials - Part 7: Criticality data for low enriched UO_2 rod lattices in water" withdrawn in January 2014 (outdated data).
- DIN 25474:2014-06 "Measures of administrative character for conservation of criticality safety in nuclear facilities excluding reactors".
- DIN 25478:2014-06 "Application of computer codes for the assessment of criticality safety".
- DIN 25712:2007-07 "Criticality safety taking into account the burnup of fuel for transport and storage of irradiated light water reactor fuel assemblies in casks" currently under review, nearly completion.

3.2. Code Validation and Development

- GRS: Current depletion calculation code KENOREST is now validated against publicly available PIE data from PWR UO_2 for actinide-only burnup credit, using both bounding and statistical approaches, to distinguish different levels of conservatism. Version is now frozen, no further development foreseen, probably besides minor bug fixes. New development of modular depletion calculation code MOTIVE has started, to replace KENOREST in the mid-term, including the new development of "Ventina" inventory calculation code in cooperation with PSI/Switzerland, for alternative use within MOTIVE framework.
- The statistical analysis tool on technical parameters SUnCISTT now features full burnup credit calculation chain, including axial burnup profiles. It is currently being extended to BWR burnup credit analysis, then including axial and horizontal assembly heterogeneities as well as consistent power, temperature and void profiles.
- AREVA: The nuclear data uncertainty analysis code NUDUNA has been extended by routines to process decay data uncertainties. The NUDUNA/MOCABA procedure for improved predictions of integral functions of nuclear data has been validated for application in criticality safety analysis. Next step is to apply NUDUNA/MOCABA to reactor core simulations.

3.3. International Collaborations

- Many bilateral and multilateral cooperations, e.g. with PSI/Switzerland, ORNL/US, and others; also international research project proposals submitted to EURATOM Horizon 2020 Nugenia, e.g. "ACUOS" (Assessment of Core Uncertainties and Operational Safety Margin, 2016-2020) F, D, E, NL, SLO, CZ.

3.4. Future Challenges

- Criticality safety research for final disposal – site / host rock comparison.
- Degraded fuel configurations (destructed assembly structures) under accident (SFP, transport) or disposal conditions.
- Transport licence application (GNS/WTI):
- Burnup (gadolinium) credit on BWR fuel.
- Quivers for damaged fuel rods (PWR, BWR) to load into T+S casks.

4. <u>Slovakia (Chrapciak)</u>

4.1. National Context (Overview)

Government Policies:

- not decided back end of fuel cycle ("wait and see")
- the work on final depository was stopped several years ago and from year 2014 has started again
- new safety reports for transport cask C-30 with basket KZ-48 and ISFSF in Jaslovske Bohunice for fuel 3.82%, 3.84% and 4.25% was issued by March 2013, licensing process was finished by March 2014 and new license has been issued

Operating Issues:

- new safety analyses for transport cask C-30 with basket KZ-48 and ISFSF in Jaslovske Bohunice for fuel 4.87% was finished by February 2014
- delay in start-up of Unit 3 NPP Mochovce increases

4.2. R&D Programmes

Code development:

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

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)

Experimental needs:

- measurement of decay heat of fuel in transport cask is in progress (methodology was already developed).

4.3. International Collaborations

- IAEA: participation on Dual Purpose Cask Safety Case (report of WASSC/TRANSSC joint working group 2011 - 2013)
- AER (Atomic Energy Research): working group "Physical problems of Spent Fuel and Decommissioning"

4.4. Future Challenges

- Urgent need for a new cask for a new fuel with higher enrichment and burn up. 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).
- Urgent need for a new storage facility, because existing wet ISFSF in Jaslovské Bohunice wil be full in year 2023. Intention is dry storage, commissioning in 2019-2020. Feasibility study is already finished, EIA study is in progress.

5. Switzerland (Vasiliev)

Update from the Swiss Federal Nuclear Safety Inspectorate ENSI (provided by J.Dus)

- There is new guideline G20 for public hearing until end of September. This guideline regulates the design and operation of the reactor core, fuel assemblies and control assemblies including the storage of fresh and spent fuel elements in the NPP facilities. This guideline can be downloaded at www.ENSI.ch, the official release is expected in January 2015.

- Concerning the fuel storage, basically the US requirements from NUREG 0800 are adopted. If BUC is applied, then the application must fulfill the standards DIN-25471 or ANSI/ANS-8.27.

- It is expected that the new guideline will lead to some updates in the existing criticality safety demonstrations for spent and new fuel storage.

- Apart that, one NPP applied for new burnable absorber credit methodology last year. ENSI has approved this methodology and found it consistent to the current international standards and criteria.

5.1. R&D Programmes

- R&D on criticality safety and burnup credit aspects specific to the final geological repository is ongoing at PSI in collaboration with NAGRA (an organization formed by nuclear utilities and the federal government and responsible for investigations for geological disposal of radioactive wastes in Switzerland and a member of swissnuclear). Apart from the geological repository case, no specific interest from Swiss utilities to BUC is currently observed.

- The major current objective at PSI remains the development of computation tools for assessment of relevant uncertainties in routine criticality calculations with the Monte Carlo code (MCNPX) and general-purpose neutron data libraries. Namely, the statistical sampling tools for propagation of uncertainties of the nuclear data (including cross-sections as well as the decay data and fission product yields in the depletion calculations) and of the technological parameters are under development and verification.

- The motivation towards the advanced uncertainties quantification methodologies development at PSI is driven by two reasons. At first, the comprehensive uncertainties data may be utilized in the updated routine CSE methodology being developed at PSI for 'standard applications' where the validation basis is significant (i.e. configurations with spent LWR fuel). However, for certain 'non-standard' types of configurations with fissile materials (e.g. originating from research or experimental reactors, etc.) the available validation basis with reasonably similar experimental configurations may be very limited and therefore more detailed uncertainties assessments as compared to the conventional methodologies/cases might be required to guarantee the criticality safety with justifiable margins.

- In parallel to that, assessments of the newest releases of the major nuclear data libraries in ENDF and/or ACE formats for calculations with MCNP(X) is continuously ongoing at PSI.

- The main tool for depletion calculations at PSI is still the CASMO-5 code with its proprietary neutron/nuclear data libraries, and it continues to be validated against experimental data available at PSI (e.g. from the LWR-PROTEUS Phase II program - i.e. reactivity worth and isotopic compositions of LWR spent fuel samples).

- To facilitate the BUC-related studies, a linking tool for transition of the CASMO-5 spent fuel composition into the MCNPX models for criticality calculations is under development. In parallel a similar tool has been developed for linking CASMO-5 depletion and Serpent criticality calculations which may serve in this sense as an alternative solution for verification purposes. SERPENT and MCNPX/CINDER depletion capabilities assessments and validation studies are also on-going.

5.2. International Collaborations

In 2012/2013 some validation studies for IRSN VESTA code have been done at PSI based on the PIE data available from the Proteus Phase-II experimental program. PSI plans to contact IRSN in 2015 for compilation of a joint publication which can include validation results obtained with the VESTA and other MC-based codes (MCNPX/CINDER, SERPENT) and also CASMO-4/5 for depletion calculations.

WPNCS EGs activities:

EGBUC

PSI has performed analysis of the BUC-VII benchmark with MCNP6, SERPENT and ENDF/B-7.1, JEFF-3.2 and TENDL2013 libraries. Some effects from the recent libraries' updates were noticed and are planned to be published. Related presentation was given at the BUC EG meeting.

EGUACSA

Additional studies are on-going for the Phase-I and Phase-II Benchmarks. Results will be published in 2014/2015. Related presentation was given at the EG UACSA meeting.

EGAMCT

PSI continues assessment of advanced MC-based depletion methodologies. A study on efficient 'hybrid' deterministic/MC-based depletion solution utilizing CASMO-5 and SERPENT codes has been initiated in 2014 and will be continued further. Performance of the hybrid solution is being assessed against SERPENT, MCNPX/CINDER and CASMO-5 stand-alone solutions.

5.3. Future Challenges

No changes since the past meeting in 2013.

5.4. Input to/from NEA/NSC Programmes of Work

EG BUC activities were of a high relevance for PSI. As was outlined above, current BUC related studies at Switzerland are oriented towards CSE for SNF disposal canisters. In that relation any potential follow-up of the past EG BUC Phase-VII benchmark will be interesting for PSI and NAGRA.

Concerning the UACSA EG activities, it seems to be useful in relation to synergy with the ICSBEP project, to complement the DICE database by estimates of uncertainties related to the applied nuclear data for the calculated k-eff values provided in DICE when possible.

6. United States

The United States has fissile material operations involving all portions of the nuclear fuel cycle. Continued delays in construction of the MOX fuel fabrication plant at the Savannah River Site have limited the need for attention to criticality safety issues involving transport or storage of MOX fuel.

With the decision to terminate further work on the repository site at Yucca Mountain, both the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) are working to assure the technical information and regulatory framework is in place to support long-term safe storage and subsequent transport of spent fuel. 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. In addition, an evaluation of the impacts of postulated failed fuel configurations with respect to criticality safety, shielding, containment, and thermal analyses was completely by the NRC that is intended to inform the safety evaluations of spent fuel storage and transportation systems.

The NRC issued in August 2014 a final rule on continued spent nuclear fuel storage, ending a two-year suspension of final licensing actions for nuclear power plants and renewals. This rule revises the Waste Confidence Decision, and adopts findings from a generic environmental impact statement that concludes spent fuel can be safely managed in dry casks for short term, long term, and indefinite time frames.

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) works to develop consensus standards for criticality safety and organize technical meetings on criticality safety. The ANS will be the US organization hosting ICNC 2015 in Charlotte, North Carolina, from 14-18 September 2015.

R&D Programmes

The DOE and NRC support research activities in the area of nuclear criticality safety. The DOE Nuclear Criticality Safety Program (NCSP) provides a central focus for research and technology development (see http://ncsp.llnl.gov/) with 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. Experiments at NCERC are conducted by Los Alamos National Laboratory and Lawrence Livermore National Laboratory. Four critical facilities at NCERC (Planet, Godiva, Comet, and Flattop) are operated as a user facility to help meet national and international program needs. The multi-laboratory Critical/Subcritical Experiment Design Team works to assess experiment needs and assure that experiments are designed and performed to achieve technical objectives. Most of the experiments are evaluated as benchmarks for dissemination as part of the Information Preservation and Dissemination program element.

MCNP, SCALE, and COG are key codes used for criticality safety within the DOE complex and are supported by the NCSP. Key code/data developments include sensitivity/uncertainty methods using continuous energy data, and the development of covariance data and Monte Carlo uncertainty analysis methods for the analysis of spent nuclear fuel compositions using SCALE.

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). An updated 10-year Mission and Vision document for the NCSP was published in October 2013.

The NRC research and development activities center on support for staff licensing activities and development of technical bases for regulatory guidance and decisions. The NRC Division of Spent Fuel Storage and Transportation issued Revision 3 of their staff guidance on burnup credit for PWR spent fuel in transport in October 2012.

The NRC Office of Nuclear Regulatory Research is supporting work to develop a technical basis for guidance on BWR burnup credit. This research was initiated in November 2013, with initial activities focusing on the burnup regime near peak reactivity. Research on developing a technical basis and approach for typical discharge BWR fuel is in progress.

The Used Nuclear Fuel Storage, Transportation & Disposal Analysis System (UNF-ST&DARDS) is a tool being developed for DOE Office of Nuclear Energy (NE) to support spent fuel management planning efforts. It combines a comprehensive relational database of US spent fuel characteristics, integrated with analysis tools to perform automated nuclear criticality safety analyses. The database is being populated with information on actual canister/cask loadings and combined with fuel assembly design information and individual assembly duty history. UNF-ST&DARDS uses this information to perform automated cask-specific criticality analyses.

The reality of very long-term storage prior to transport of spent fuel has prompted both DOE and NRC to seek a better understanding of the failed fuel scenarios that could lead to a potential for criticality. DOE is also re-assessing approaches to address the potential for criticality in repositories. As DOE studies future options for storage, transport, and disposal systems, efforts are being made to increase available validation data, access a broader set of actual operational data, and improve approaches for estimating uncertainties. Neutron absorber degradation in spent fuel pools and the potential consequential impact on criticality safety has been a priority issue for NRC in 2013.

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.

In March 2014 and July 2014, representatives from the NCSP met with representatives from the UK AWE and IRSN to discuss collaborative work tasks that would be initiated in 2015.
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.

As part of the OECD Working Party for Evaluation Cooperation (WPEC) CIELO (Collaborative International Evaluated Library Organization) Project, multiple US national laboratories (ANL, BNL, LANL, and ORNL) continued work with other international partners to improve nuclear evaluations for ^{1}H, ^{16}O, ^{56}Fe, ^{235,238}U, and ^{239}Pu that are needed for nuclear criticality safety.

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.

To address holdup residues that 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.

Validation data (e.g., isotopic assay data and critical experiments) for use in safety analyses using burnup credit has improved significantly in both quantity and quality over the last two decades. However, the focus has been on burnup credit for PWR spent fuel burnup credit and obtaining the same quantity and quality of data for BWR systems is difficult, particularly given the diversity and complexity of BWR assembly designs and operating conditions. Similarly, validation data for degraded/failed fuel configurations are lacking and may become an important, but challenging issue if evaluations of such configurations become the limiting state for transport or disposal of spent fuel.

Evaluations have been conducted by DOE-NE investigating the feasibility of direct disposal of dual-purpose (storage & transportation) canisters into various geologic host media. One of the major technical challenges is demonstrating the sub-criticality of the spent nuclear fuel for the lifetime of the repository. A scenario of particular interest is the event of the disposal

canister(s) becoming flooded by ground water. Disposal criticality analyses have been applied using the UNF-ST&DARDS methodology to credit assembly- and canister-specific attributes in conjunction with modified canister internal configurations to account for internal basket degradation.

6.1. Input to/from NEA NSC Programmes of Work

The US continues to engage in each of the Expert Groups of the Working Party on Nuclear Criticality Safety. These engagements are sponsored by numerous agencies, but the DOE/NNSA or NRC are the primary sponsors of the participants and their contributions.

Under the NEA Committee on the Safety of Nuclear Installations (CSNI) Working Group on Fuel Cycle Safety (WGFCS), a new activity proposed by the US, Operational and Regulatory Aspects of Criticality Safety, was initiated and is focusing on a review of national activities, plans and regulatory approaches for criticality safety in the following areas: fuel enrichment and fabrication operations, radioisotope production, waste management operations, reprocessing operations, transportation of fissile materials, and other operations or activities in which nuclear criticality safety is of concern.

There is value in assuring a dialogue between the CSNI and the NSC to assure this new CSNI activity is aware of the past and current activities of the WPNCS.

7. UK (O'Connor)

7.1. Government Policies (related to issues discussed)[1]

Following decades of decline in the nuclear industry, a UK government review of energy policy in 2006 gave the green light to a new generation of nuclear power. However, any new reactors would need to be wholly financed and built by the private sector with no direct subsidy.

[1]Sources:
http://namrc.co.uk/industry-intelligence/uk-new-build-plans/;
http://namrc.co.uk/industry-intelligence/uk-new-build-plans/developers/;
http://www.guardian.co.uk/environment/2012/jul/20/china-uk-nuclear-power-plants;
http://www.theguardian.com/politics/2013/jul/05/davey-minister-nuclear-power-hinkley-point;
http://www.edfenergy.com/about-us/energy-generation/new-nuclear/;
http://www.horizonnuclearpower.com/technology;
http://www.nugeneration.com/our_plan.html;
http://www.nda.gov.uk/news/plutonium-management-alternatives.cfm;
http://news.onr.org.uk/2014/08/hitachi-ge-design-for-new-nuclear-power-station-clears-first-regulatory-assessment-hurdle/; http://www.energypost.eu/saga-hinkley-point-c-europes-key-nuclear-decision/; http://www.world-nuclear-news.org/NP-UK-government-paves-way-for-Chinese-nuclear-plant-18061401.html
http://www.theguardian.com/environment/2014/mar/11/russian-nuclear-firm-build-power-station-uk

There are plans to build up to 16GW of new nuclear power capacity (€70 billion). Eight sites around the UK have been identified as suitable for new nuclear power stations by 2025 (Sellafield, Sizewell, Hinkley Point, Oldbury, Wylfa, Bradwell, Heysham and Hartlepool), all of which contain existing nuclear plants.

Three reactor designs are currently being considered for UK new build: Areva's European Pressurised Reactor (EPR) (1600MW), Westinghouse's AP1000 (1150MW) and Hitachi's Advanced Boiling Water Reactor (ABWR) (1350MW).

The generic design assessment (GDA) for AREVA's EPR was completed by the Office for Nuclear Regulation (ONR) in 2012. Westinghouse's AP1000 reactor has also completed its GDA and interim acceptance has been granted. Westinghouse do not intend to address their issues until a customer for the AP1000 has been secured. The initial high level GDA for Hitachi's ABWR has been completed and no fundamental safety, security or environmental issues have been identified. The assessment will now move to the next more detailed stage with a target completion date of December 2017.

EDF Energy propose to build four EPRs at the Hinkley Point and Sizewell nuclear sites. A strike price for the electricity generated has been agreed with the UK government. However, the European Commission will need to confirm that this agreement meets EU law on state aid. It is anticipated that a ruling may be given by the end of 2014. It is possible that China may partner EDF Energy with the investment for Hinkley Point C.
Horizon Nuclear Power, was purchased by Hitachi-GE Nuclear Energy Ltd is planning to provide at least 5.2GW of new nuclear capacity to the UK. It is possible that an ABWR could be built at Wylfa.

NuGeneration, a joint venture between Iberdrola and GDF Suez, is intending to build 3.6GW of new capacity. A reactor design has yet to be selected; final decision is expected around 2015 with a view to starting production in 2023.

The UK Government has also agreed in principle for Chinese companies to own and operate Chinese designed nuclear power plants in the UK. A memorandum of understanding has also been signed within the last year between Russia and the UK in preparation for their entry in UK civil nuclear market.

Although the Sellafield MOX Plant (SMP) closed in 2011, due to reported technical and commercial failures, the preferred policy of the Nuclear Decommissioning Agency (NDA) to deal with the UK's plutonium stocks is to convert the material into MOX for commercial light water reactors (LWR). A second MOX plant could therefore be built.

However, other options are being considered for the disposition of the plutonium. For example, there is the Enhanced CANDU 6 reactor and the American fast PRISM reactor by General Electric-Hitachi. The PRISM reactors would be built as a pair at Sellafield and would be attractive to the UK taxpayer as there would be no up front cost. Instead a charge would be levied per kg of plutonium disposed. The NDA will consider the output of the feasibility studies currently in progress. Licensing and operation could potentially occur within a decade.

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

In March 2013, the UK government set out its Nuclear Industrial Strategy allowing a coordinated approach to the UK's future nuclear research and development demands. The Nuclear Innovation Research Advisory Board (NIRAB) and the Nuclear Innovation and Research Office (NIRO) are now operational although it is too early yet for any impact to be made.

Source: https://www.gov.uk/government/organisations/department-for-business-innovation-skills/series/nuclear-industrial-strategy

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

The UK Working Party on Criticality (WPC) has been working with the Nuclear Industry Fire Safety Coordinating Committee (NIFSCC) in order to produce a more holistic ALARP approach in the provision of fire fighting advice.

In August 2014, EDF Energy reported that the four nuclear reactors at its Heysham 1 and Hartlepool power stations would be shut down to allow a detailed programme of boiler inspections to take place.

This precautionary measure was taken after the discovery of a crack on a component known as a 'boiler spine' at Heysham 1. Hartlepool power station was also shut down because both stations share the same unique design with each of its 16 boilers supported by this 'boiler spine' component.

Other advanced gas-cooled reactors in the UK have a different and more conventional boiler design without a 'boiler spine' and they are manufactured from different materials. Therefore there is no risk that they could suffer from the same issue.
EDF Energy expects there to be a phased return to service by the end of 2014.

Source: http://newsroom.edfenergy.com/News-Releases/EDF-Energy-update-on-Heysham-1-and-Hartlepool-Power-Stations-2e5.aspx

7.4. R&D Programmes

Code development

The MONK neutronics code is currently the UK industry standard however there is increasing interest in other codes such as MCNP.
The latest version of MONK is 9A. This code is developed by the ANSWERS software service, currently part of AMEC (used to be SERCO).
MONK10A is due to be released in 2015. The BINGO continuous energy nuclear data libraries based on JEFF3.1, ENDF/B-VII and CENDL3.1 have been produced and are being used with the MONK verification and validation test sets.
Development versions of MONK include a CAD (computer aided design) import capability as well as the ability to parallel process burnup calculations. This novel parallelization method is based around the use of distributed computing elements.
The graphical visualization program, Visual Workshop, used with MONK allows the user to view their input models in 3D (with the use of 3D goggles). The program can also be used to view the location of the neutron action events that occurred in the system to produce the final value of k_{eff}.

Sellafield Ltd, previously British Nuclear Fuels Plc (BNFL), is in possession of the source code and intend to develop MONK separately to ANSWERS.

7.5. Experiments, Facilities, Skills/Staff requirements

There is a large amount of old experimental data at various UK sites, for example Dounreay. UK funding is required to write up this information; although some is being written up on a best endeavours basis.

7.6. International Collaborations

Ongoing

ISO standard on waste [from a criticality perspective], the IAEA guide on criticality safety, ICSBEP (International Criticality Safety Benchmark Evaluation Project), JEFF (Joint Evaluated Fission and Fusion) Scientific Co-ordination Group, IRPhE (International Reactor Physics Benchmark Experiments), various ANS Nuclear Criticality Safety Division committees / ANS.8 standard committees and various OECD/NEA expert groups the Working Party on Nuclear Criticality Safety (WPNCS).

The US Department of Energy (DOE) are actively collaborating with the UK Atomic Weapons Establishment (AWE) on various technical aspects of the US DOE Nuclear Criticality Safety Program. Both the National Nuclear Laboratory (NNL) and the UK Working Party on Criticality (WPC) are looking into how UK involvement in this can be expanded; NIRAB and NIRO may be able to assist in this respect.

IRSN and AMEC have recently been contracted by the ONR to carry out transport package reviews from a criticality safety, shielding and engineering perspective.

Planned

Time and money issues are impacting on the UK nuclear industry to get involved in various international activities. The UK is aware that there is insufficient coverage of various OECD/NEA and ANS standards committees. There is also inadequate UK funding to appropriately support nuclear data activities such as ICSBEP. In particular, the UK Nuclear Science Forum (UKNSF) used to monitor and interface with related international activities. Although it has not met for a number of years due to funding issues, it has informally met in the last few months.

7.7. Future Challenges

Development activities within the field of criticality and sharing information / best practice has deteriorated over the last few years. Namely due to fragmentation of the site licensing companies, increased commercial pressures, increased focus on intellectual property rights and the closure of various industry bodies.

UK funding is needed to support various international activities and to write up old experimental data.

Due to the anticipated new nuclear build, the current skills capability of the UK will also need to be increased.

UK funding for the NEA has been secured up to the end of 2015. A business case for beyond this date is currently being developed.

The revised fissile exception criteria in the new IAEA transport regulations SSR-6 (2012) will become UK law in 2015. In line with other member states, this will present challenges to both the operators and the UK Competent Authority in regard to the

implementation of the new provisions and approval of the material as being fissile excepted respectively. Discussions are underway in the UK to develop a methodology for the approval of applications for material to be classed as fissile excepted under one of the new provisions.

Approval for the GDF (Geological Disposal Facility) safety case is ongoing. The operation of such a facility is still considered to be a number of decades in the future.

Draft for approval

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

18th Meeting of the Working Party on Nuclear Criticality Safety

(WPNCS)

Friday September 19, 2014

NEA Headquarters, Issy-les-Moulineaux
France

AGENDA
Meeting venue : NEA Room A+B, 7th Floor

Proposed Meeting Schedule: 9h00 – 18h00

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

ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT
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