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NUCLEAR ENERGY AGENCY
NUCLEAR SCIENCE COMMITTEE

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Working Party on Nuclear Criticality Safety (WPNCS)

Thirteenth Meeting of the Working Party on Nuclear Criticality Safety

SUMMARY RECORD

25 September 2009
Idaho State University, Pocatello, USA

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ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT

Nuclear Energy Agency
Nuclear Science Committee
Working Party on Nuclear Criticality Safety

THE THIRTEENTH MEETING OF THE WORKING PARTY ON NUCLEAR CRITICALITY SAFETY

25 September 2009

Idaho State University, Pocatello, USA

SUMMARY RECORD

1. Introduction

Rouyer, the WPNCS chair, opened the meeting and welcomed the delegates. Sixteen delegates attended the meeting (see the list of participants in Annex 1).

2. Review of actions from the previous meeting (Annex 4)

Feedback from the Workshop on Needs of Research on Nuclear Criticality Safety for future nuclear systems will be discussed under item 10.

3. Approval of the summary record

[NEA/SEN/NCS/WPNCS(2008)2]

The Summary Record of the previous meeting was approved without modification.

4. Feedback from the Nuclear Science Committee (NSC) meeting

During the last NSC meeting (June 2009), **Rugama** reported on the progress of the Working Party and its Expert Groups. He informed the participants of the Working Party that the progress and publications on LWR fuel cycle was greatly appreciated by the committee. The organisation of the ICNC2011 conference was also presented.

5. Nuclear Criticality Safety National Programmes (Czech Republic, Finland, France, Germany, Japan, Sweden, Switzerland, United Kingdom, USA, International organisations)

Czech Republic

Markova informed the Working Party that on 1 June 2009 the latest VVER-440 PIE proposed and funded by the Consortium of the EU member countries operating VVERs (Bulgaria, the Czech Republic, Finland, Hungary and Slovakia) finally started as # 3958 ISTC project in the laboratory of RIAR, Dimitrovgrad (Russia). 12 samples of VVER-440 KOLA NPP (Russia) spent FA with average burnup B_{aver} of 56.5 MWd/kgU are examined. Isotopics of 27 'BUC' isotopes and the burnup monitors will be measured. The project will take 18 months. . In the course of the year 2009, two new NRI projects aimed at PIE data evaluation and repository issues gained funding, a grant application for another project focusing on the code validation was submitted.

Finland

Mattila informed the participants about the nuclear criticality safety program in Finland. A summary is provided in Annex 2.

France

Rouyer and Santamarina presented an overview of the French criticality program. The fuel cycle industry progress report was summarised, stressing that the Hague reprocessing plant treats a wide diversity of fuels and that the construction of Georges Besse II (centrifugation uranium enrichment plant) is progressing very well. BUC is planned to be applied on BWR and PWR (MOX) fuel on the Hague plant as well as in transport.

Rouyer added that a Criticality Safety Analysis guide is in preparation in France, and a summary will be made available in English. She also provided some details about the experimental program MIRTE II as continuation of MIRTE I related to the study of non-fissile materials (concrete, iron, copper, …). Discussion among participants (IRSN, French industry and the DoE) on this new programme is currently undergoing. The following materials have been presented as the preliminary list (**Cr, Cl, Mn, Mo, Hf. Rh-103**).

Santamarina presented the CEA experimental program for PWR-BUC applications to take into consideration isotopic penalty factors from PIE. Details on the analysis were provided to the delegates that asked if the data will be openly available. The French delegates took note of the interest to make available the data and added that this work has been performed in collaboration with the French industry, and an agreement needs to be reached among all participants. Santamarina briefly discussed the CEA contribution to the different EGs of the Working Party.

Germany

Neuber informed the participants about the Criticality Safety programme in Germany,in particular waste disposal related activities. Good progress has been achieved on the licensing report for final disposal, a draft version is under study. He added that the risk inform approach has been used for waste disposal applications during operation and post-closure phase.

Japan

Miyoshi reported on the current activities of Nuclear Criticality Safety in JAEA. Vitrification problems in the Rokasso reprocessing plant have delayed MOX fabrication activities in Japan. He also presented current activities at the Nuclear Fuel Cycle Safety Engineering Research Facility (NUCEF).

Miyoshi presented the critical experimental programs in the TRACY and STACY experimental facilities. A new experimental program is being designed to study the static and kinetic features of next generation fuels for LWR reactors: high burn-up and higher 235U initial enrichment(above 5%).

Miyoshi added that the evaluations in the Japanese criticality safety handbook will be fully based on MVP +JENDL3.3. He acknowledged the strong collaboration organised between JNES and JAEA on Post-irradiation examination experimental data.

Sweden

Mennerdahl apologised for his absence and sent a report on the Swedish criticality safety activities that was read by **Rugama .** Note that the report has been added entirely**.**

1. The industry organisation responsible for final disposal of spent fuel has determined the site for the disposal. This is at the Forsmark site where there are currently 3 BWRs and a final disposal for LLW (low-level waste) and MLW (medium-level waste). There were two alternatives, and the local population and politicians at both sites were in favour of the disposal. A license application is planned for 2010 and the disposal is planned to be opened in 2023.

2. The current government, consisting of a coalition of four parties, recently agreed to allow replacement of reactors taken out of service permanently. The current 10 reactors (7 BWR, 3 PWR) may thus be replaced with other reactors. The change of policy was allowed by one government party that previously sided with the opposition which still wants nuclear power to be phased out after the current 10 reactors go out of operation. A new election could thus reverse the government position. However, the change is important. The largest opposition party is split on the nuclear issue and the large unions (often connected to that party) are in favour of preserved nuclear power capacity. The government is not supporting financially the development of nuclear power.

3. There has been a problem (cracks) with control rods for BWRs in Sweden. It is serious and has caused considerable downtime of several reactors. **Mennerdahl** says he has not followed this closely enough to report on it.

Switzerland

Kolbe briefly presented the BUC applications activities performed in Switzerland. He commented that at present BUC has been applied to PWR wet storage pools and it was based on the BOXER 2-D transport code. The near term goal is to upgrade the analysis methodology to the use of CASMO-4 for depletion calculations and MCNPX for criticality analyses. The validation of the former is on-going in parallel, mainly on the basis of Swiss spent fuel data.

UK

Gulliford informed the participants on the activities related to criticality safety in the UK. Some recent studies have showed some difficulties on identifying scenarios of incidents for low level waste disposal. He added that an international collaboration on this subject could be envisaged within the WP.

Gulliford summarised the UK activities on post-closure criticality applications. Developments in computer codes (MONK, WIMS, etc.) were briefly detailed as well as the activities related to knowledge preservation.

USA

Rearden presented the Nuclear Criticality Safety Program (DOE/NCSP) in the USA. For details on the Mission and Vission plan , please visit the website: http://ncsp.llnl.gov. **Rearden** informed the participants about the integral experimental programme launched in the USA.

Barto added that the U.S. NRC is reviewing the license application for a gas centrifuge enrichment facility and a MOX fuel fabrication facility, which included the review and approval of criticality safety systems. Global Laser Enrichment license application is under review.

In the area of criticality safety for disposal, the U.S. NRC has received and docketed the license application for Yucca Mountain. Current design for post-closure criticality safety involves the use of burn-up credit. He stressed that with regard to spent fuel transport cask designs, the U.S. NRC has approved one cask design with burn-up credit, and another one is pending as part of the criticality safety system. Two other

transportation cask designs with burn-up credit are currently under review. Revision of Interim Staff Guidance (ISG) 8 on burn-up credit for storage and transportation is under revision.

International Organisations

- *ISO standards*

  On behalf of Calvin Hopper, **Gulliford** gave a brief overview of how on-going projects at the ISO Technical Committee 85 (TC85)/Working Group Criticality Safety (WG8) are progressing. He described projects of potential interest to the working party and those that have been proposed at the last meeting at the UK in June 2009.

6. Reports from the WPNCS Expert Groups

- ***Source Convergence (Brown)***

  Brown outlined the main progress achieved by the Expert Group on Source Convergence.

  Brown acknowledged the outstanding work performed by Roger Blomquist, former chair of the EG, who will not be able to participate in the future to the WP activities due to the lack of funding. He added that an excellent example of the development and transfer of Monte Carlo technology to practitioners has been provided by the Expert Group on Source Convergence Analysis during the last years. Longstanding difficulties were resolved, and new techniques for assuring correct source convergence have become established, routine tools for practitioners. He presented the schedule discussed during the meeting to complete the guidance report already under preparation since the last meeting.

  Brown informed the delegates that the experts proposed to dissolve the EG on source convergence and create a new EG on Advance Monte Carlo Techniques for Criticality Safety practitioners. He presented the outline of the new EG mandate with main objective and a potential list of participants. The participants agreed with the proposal and the drafted mandate and added that before starting the activities of the new EG, the guidance report on source convergence should be completed.

- ***Criticality Excursion (Miyoshi)***

  Miyoshi summarised the outcomes from the last meeting. Results from the benchmark exercise Phase II were presented by the different contributors (JAEA, IRSN and CEA). He presented the publication schedule; the first draft version is expected by the end of May 2010.

  Final results from Phase I of the exercise to study the effect of the approximations, made by code users, on the description of the geometry were extensively discussed. The participants agreed on the details on the specifications for the Phase II of this exercise.

- ***Assay Data for Spent Nuclear Fuel (Rearden on behalf of Ian Gauld)***

  Rearden reported on the outcome of the third meeting of Assay Data for Spent Nuclear Fuel EG. During the meeting, the final draft of the state-of-the art report for assay data of nuclear spent fuel was extensively discussed. Final version for reviewing is expected by the end of the year. **Rearden** highlighted that experimental data sets compiled the last year expand the number of samples from 246 to more than 400 samples.

Finally, **Rugama** announced that a voluntary contribution from Spain to the NEA is expected by the end of the year. The main purpose is the organisation of the evaluation of two recent sets of experimental data plus the drafting of a guidance report to evaluate assay data.

- ***Uncertainty Analysis for Criticality Safety Assessment (Ivanova)***

Ivanova informed the delegates about the results of the second meeting of the Expert Group on Uncertainty Analysis for Criticality Safety Assessment. The EG discussed extensively the publication of a state-of-the-art report that compares the different methods and tools in use for a criticality safety assessment and the benchmarking of the methods. Final results from the Benchmark exercise Phase I would also be included in the report. The final draft is expected in November 2009.

Specification of the Phase II were also briefly introduced by **Ivanova** and **Neuber**. **Santamarina** proposed that a blind test without a reference calculation should be included in the specifications. He added that this test would better reflect the performances of the different methods.

Neuber added that the publication of preliminary documents was discussed during the meeting. He stressed that preliminary results should be kept as working documents and the outcome of comparisons should be discussed in the expert group meetings before distribution in open fora.

7. Status of the ICSBEP (Briggs)

Briggs described the activities of the International Criticality Safety Benchmark Evaluation Project (ICSBEP). The September 2009 issue of the handbook contains first evaluations of a series of ZPR integral experiments.

8. Experimental needs (All)

No new programme or need was discussed during the meeting; however the delegates agreed to maintain the item on the agenda for future experimental needs that need coordination from the WP. The interest of reactivity worth measurements by the oscillations technique for studying the use of fission products on BUC applications was highlighted by **Gulliford** and **Santamarina**.

9. ICNC conferences (Technical Program)

Gulliford presented the UK working group and the local committee responsible for organising the ICNC 2011. He also distributed some flyers announcing the conference. A draft version of the sessions was also presented.

Gulliford and **Rugama** will distribute to the delegates the draft version of the ICNC2011 programme proposed by the Local committee. Comments from the Technical Programme committee would be considered in the final version.

10. Feedback on the Workshop on Needs of Research on Nuclear Criticality Safety for future nuclear systems

The delegates express gratitude to George Imel, chair of Nuclear Engineering Department of the Idaho State University and local organiser, for the impressive organisation and welcoming.

The participants agreed that the chairs of each session would summarise the highlights of the talks and draft conclusions. A report of 2-3 pages per session should be produced before November 2009. **Rouyer**

and **Rugama** would compile the summaries that would be distributed to the Working Party for discussion at the next meeting. **Gulliford** proposed that a report should be prepared.

One of the conclusions of the workshop is that we need more MOX experimental data and good correlation data between experiments. The increase interest on the use of uncertainty and sensitivity analyses was highlighted during the workshop, by consequence, the need of confident covariance data.

11. Date and place of the next meeting

The delegates agreed that most part of the EG would meet on the same week of the WP. The tentative location and dates are: NEA offices, 6-10 September 2010.

ANNEX 1

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ANNEX 2

Current Issues regarding Nuclear Criticality Safety in Finland

Issues and activities concerning criticality safety of fuel storage and transportation

In general, the fundamental Finnish approach to criticality safety in storage and transportation of fuel has been to use "robust" storage designs with significant margin for the most reactive fuel assemblies currently in use. As an example, all fuel storage arrangements for the OL3 plant (currently under construction) have been dimensioned for fresh fuel with 5 % enrichment and no Gd. This – along with the fact that there is relatively limited need for transportation of spent fuel - has limited the urgency to develop methodology for improving criticality safety assessments in comparison to some other countries.

Some items that are currently demanding further research:

1. There are projects aimed at increasing fuel discharge burnup, which leads to higher initial enrichments and thus higher reactivity of fresh assemblies. This will reduce the criticality margins in the existing storage systems, and introduction of BUC methods will possibly be needed in the future in order to use the existing fuel storage systems with the new, more reactive fuel.

2. The direct final disposal of spent nuclear fuel, selected as the reference method in Finland, will pose new questions, such as the long-term structural and chemical integrity of the fuel assemblies. The long time-scales will also change the relative importance of different nuclides from the point of view of criticality safety. In addition, predicting the decay heat, which is the factor limiting the overall storage density of the final repository, requires accurate prediction of the concentrations of some nuclides that have previously been of lesser importance.

3. The practical implementation of the criticality safety calculation system to utilize standardized and automated procedures for determining the limiting multiplication factor for new fuel types in all relevant storage arrangements will reduce the probability of human errors in the criticality safety calculations. Such methods and codes (MCNPLINK for BWR and PWR fuel and FNSLINK for VVER fuel) have been (or are in the process of being) taken into use in the licensing procedures of new fuel types.

4. The safety authority needs to have an independent tool for criticality safety analyses for evaluating and assessing the analyses performed by the utilities. This is best achieved by developing own analysis tools. In addition, this provides an excellent opportunity for new people to get hands-on experience on the important issues in reactor physics and safety analyses. The national nuclear safety research programmes have proven a good framework for such development projects.

Research and development projects related to all these issues are going on at the utilities as well as the Technical Research Centre of Finland (VTT), with some being linked to burnup extension projects, and others included in the national nuclear safety research programmes (the current one is named SAFIR2010 and has its own web pages at http://virtual.vtt.fi/virtual/safir2010/).

Criticality safety of fuel in reactor

When fuel is located in a reactor, the criticality safety cannot be guaranteed with a similar robust geometrical approach as is the case with fuel storage arrangements: the geometry of the core is such that it does enable the fuel to go critical, if the means to control the reactivity (boron, control rods) are for some reason lost. Three main issues are being looked at:

1. Prevention of boron dilution during refueling outage. The routes through which the non- or lightly-borated water might enter the primary circuit have been mapped several times, and improvements – mainly administrative arrangements and changes in the boron content of different waters used at the plant – have been made. The most recent development in this field has been the introduction of constant boron measurement devices (borometers) in the lines that are used to feed water to the primary circuit. These devices are able to immediately detect anomalies in the boron concentration of the water being fed to the primary circuit, and thus constitute a much faster way to detect boron dilution than the laboratory analyses made of the primary circuit water.

2. In BWR:s, where the subcriticality is based entirely on the control rods, the procedures followed during the refueling and maintenance outages have been re-evaluated, and some minor changes have been made in order to minimize the need for moving control rods in such a way that the protection systems are not in full operational state. Especially the changes in plant operational states, and the procedures used to ascertain the functionality of the protection systems prior to these changes, have been looked at.

3. When new fuel assemblies are being loaded in the core, it is necessary to minimize the possibility of human errors to affect the core reactivity. In the recent years, there have been several occasions around the world in which the procedures to prevent misplacement of fuel assemblies have proven insufficient – the latest one during Loviisa 1 refuelling in August 2009, when one control assembly was missing from the core after reloading: even though all reloading operations had been made according to the fuel assembly transfer plan, one assembly had not been transferred along with the reloading machine, and this was not noticed by the people supervising the fuel transfers. In the case of large PWR:s, where constant monitoring of source range flux in order to detect approaching local criticality is not feasible, special arrangements are needed to ensure criticality safety in spite of a serious human error occurring e.g. during reloading, core design (wrong input data for assembly burnup codes etc.) or fuel procurement (missing Gd rods, wrong enrichment etc.).

In conclusion, even though the Finnish principal approach towards criticality safety is (and has always been) to use so much margin that the criticality safety can be ascertained with relatively simple and straightforward analyses, there are several issues (increased burnup, final disposal etc.) that make further methodology development necessary. However, from the criticality safety point of view, it appears that the most urgent issues are in the field of reducing the reliance of correct human operation, especially when the fuel is in the reactor and the subcriticality cannot be ensured by the straightforward storage geometry approach.

ANNEX 3

LIST OF ACTIONS

Action number	Action holders	Description of the action	Due dates
WPNCS-2009.1	Chairs workshop	Send their summaries before November 2009	November 2009

ANNEX 4

Nuclear Energy Agency
Nuclear Science Committee

THIRTEENTH MEETING OF THE WORKING PARTY ON NUCLEAR CRITICALITY SAFETY

Idaho State University, Pocatello, USA

25 September 2009

9:30 AM to 5:00 PM

PROPOSED AGENDA

1.	Welcome and administrative items	*V. Rouyer*
2.	Review of actions from the previous meetings	*Y. Rugama*
3.	Approval of the summary records of the previous meeting	*ALL*
4.	Feedback from the Nuclear Science Committee meeting	*Y. Rugama*
5.	ISO standards	
6.	Nuclear Criticality Safety National Programmes and IAEA activities	*Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, Spain, Switzerland, UK, USA*
7.	Reports from the WPNCS Expert Groups:	
	• Burn-up Credit	*M. Brady Rapp*
	• Source Convergence Criticality Excursions	*F. Brown* *Y. Miyoshi*
	• Assay Data for Spent Nuclear Fuel	*T. Ivanova*
	• Uncertainty Analyses for Criticality Safety Assessment	
8.	Status of the ICSBEP	*B. Briggs*
9.	Experimental needs	*ALL*

10.	ICNC conferences/ICNC 2011 Current Status	*J. Gulliford*
11.	Feedback on the Workshop on Needs of Research on Nuclear Criticality Safety for future nuclear systems	*ALL*
12.	Date and place of the next meeting	
13.	Adjourn	