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**NUCLEAR ENERGY AGENCY
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Or. Eng.

**NEA/SEN/NSC/WPPR(99)4
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Working Party on the Physics of Plutonium Recycling and Innovative Fuel Cycles

**SUMMARY OF THE NINTH MEETING OF THE
WORKING PARTY ON THE PHYSICS OF PLUTONIUM RECYCLING
AND INNOVATIVE FUEL CYCLES (WPPR)**

**18-19 November 1999
NEA Headquarters, Issy-les-Moulineaux, France**

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**NINTH MEETING OF THE WORKING PARTY ON
PHYSICS OF PLUTONIUM FUELS AND INNOVATIVE FUEL CYCLES (WPPR)**
18-19 November 1999

Summary

Introductory Remarks (1)*

1. The chairman Kevin Hesketh opened the meeting and welcomed the participants.

Objectives of the Meeting (1a)

2. The chairman explained that the principal objectives of the meeting were to discuss the revised results of the BWR Benchmark and to agree as to whom would draft Volume 7 and the corresponding timescales.

Introduction of Participants (1b)

3. The list of participants is provided as Annex 1.

Review and Approval of the Agenda (2)

4. The Agenda was approved with the addition of an extra item under 6 to discuss the Fifth Framework proposals from Siegfried Langenbuch. (see Annex 2). The actions from the previous meeting were then reviewed. The list of papers distributed at the meeting and others relative to the WPPR9 are provided as Annex 3.

Summary of discussion on VENUS-2 Benchmark (3)

5. The chairman briefly summarised the outcome of the VENUS-2 Benchmark for the benefit of those who were not present at the TFRPD meeting. Thirteen solutions were submitted and the agreement is generally satisfactory (< 500 pcm reactivity, 5 percent on power in the UO₂ regions and 10 percent power in the MOX region). The higher spread of pin powers in the MOX region is partly a result of the MOX rods being positioned at the core periphery and therefore more influence by boundary effects.

* *Note: the numbers correspond to items on the agenda (see Annex 2)*

BWR MOX Benchmark (Phase III) (4)***Summary of Solutions Received (4a)***

6. Andrei Tchistiakov and Marc Delpech presented a summary of the twenty solutions received. As with the preliminary results discussed at WPPR8, the solutions were in satisfactory agreement. Some minor anomalies were noted, including a large spread for the WIMS-based solutions, even though all used variants of the JEF library. Mr. Lance agreed to investigate whether alternative group representations or other methods choices within WIMS might cause the observed spread.

7. To further assist with interpreting the results, it was agreed to request additional information concerning details of the group structure and burnup steps, details of the ^{155}Gd and ^{157}Gd distributions at 8.0 and 12.0 MWd/kgU, in addition to the 10.0 MWd/kgU step originally requested. It was also agreed to request details of microscopic cross-sections and number densities for input to a comparison program that CEA have already prepared. Details for additional information to be provided and comments received from W. Timm after the meeting can be found in Annex 4.

ACTION : Benoit Lance to investigate the possible reasons for the spread in the WIMS-based solutions.

ACTION : Participants to respond to the questionnaire distributed at the meeting if possible by end-January 2000.

Presentation of Solutions by Participants (4b)

8. Detailed presentations were made by Belgonucleaire (Lance), ORNL (Ellis), TODEN (Saji) and Kurchatov (Kalugin).

9. Belgonucleaire used WIMS8, with the WIMS97 library (based on JEF2.2), with 172 groups in the spectral calculations and a condensation to 8 groups for the characteristics (CACTUS) solution for the whole assembly. The gadolinia pins were sub-divided into 7 annular regions, with a total of 10 rod distinct types represented.

Steps for Completing the Benchmark (4d)

10. It was agreed to attempt to complete the draft of Volume 7 by end-May 2000, in time for WPPR10. Drafts of Chapters 1 and 2 were circulated prior to this meeting together with detailed changes suggested by Messrs. Timm and Schlosser. Participants were asked to provide further comments on the revised draft (to be circulated with the notes of this meeting) by end-March 2000.

ACTION : Participants to provide comments on the revised Chapters 1 and 2 by end-March 2000.

Status of release of other benchmark experiment (5)

11. There was a short discussion on the status of other benchmark experiments that might become available. Marc Delpech said that the tight lattice PWR ERASME data was unlikely to become available, but fast reactor data from MASURCA might be released.

12. It was noted that data from ISTC 371.2 might become available. This will be based around the BFS reactor, but it is not yet definite that it will go ahead.

ACTION : Marc Delpech to check if the MASURCA data could be made available.

Results from Different Projects (6)

Status of IMF Benchmark (6a)

13. Jean-Marie Paratte presented the results of the PSI Benchmark on Inert Matrix Fuels. The agreement on most of the physics parameters is reasonably good, but there were some discrepancies, notably in the calculation of β_{eff} . The benchmark represents various IMF rods (Al_2O_3 , ThO_2 , ZrO_2 etc) at the centre of a 5x5 mini-lattice of conventional UO_2 or MOX rods. Participants include CEA, ECN, JAERI, KAERI, PSI and Skoda. The k-infinity results for the whole problem are within 500 pcm, but the UO_2 or MOX rods dominate the lattice. The spread of k-infinities for the IMF rods on their own is much larger and there are diverging solutions with burnup. This is perhaps not too surprising given the heavy depletion of the fissile isotopes during burnup – the residual ^{239}Pu content can become as low as 5 percent of the original number density. BOL reactivity coefficients are in good agreement, but there is divergence at high burnups. The Doppler coefficient at EOL is very small, in some cases almost zero. It was noted that ENDF-B4 gave very different reactivity coefficients to ENDF-B5 & B6 and JEFF, thought to be due to older zirconium data not having been updated.

14. The next phase will be an IMF assembly adjacent to 3 UO_2 assemblies. The initial results show a similar spread for the k-infinity of the IMF assembly as for individual IMF pins. However, the peak power in the configuration is quite well predicted (~ 1 percent to 4 percent).

Status of ADS benchmark and Benchmark on Power Distribution within Assemblies (6b and 6c)

15. Byung Chang Na summarised the status of the accelerator driven systems (ADS) benchmark and the within-assembly power distribution benchmarks. CEA have looked at the effects of uncertainties in the nuclear data on k-effective, which is around ± 2 per cent.

Status report from WPEC and JEF Project (6d)

15. Claes Nordborg and Robert Jacqmin gave presentations on the present status of the WPEC and JEFF projects. The former WPEC and WPMA working groups are now merged and there has been a rationalisation of sub-groups. The JEFF3T starter file is now available for testing and the first full release is expected in early 2002.

Proposal of a Project for the EU 5th Framework Research Programme (6e)

16. There was a discussion of the proposal from Langenbuch for a Fifth Framework programme “The Verification of Neutronics Analysis and Design Codes for High Burnup Uranium and MOX Fuel”. It was commented that the proposal as circulated to the WPPR was too sketchy, but it is understood that a more detailed proposal has subsequently been prepared. The WPPR members agreed that it was important to coordinate closely with this project, if it is approved, and welcomed the possibility of European research funds being available to support this kind of work.

Meetings of Interest to the WPPR (7)

Next Workshop on Advanced Reactors with Innovative Fuel Cycles (ARWIF-2001) (7a)

17. The proposed ARWIF-2001 workshop was discussed. The WPPR members agreed that a special topic of high conversion reactors would be useful as a means of ensuring existing expertise is not lost. Other areas suggested for inclusion were studies on the gas cooled fast reactor (GCFR), high temperature gas reactors (HTRs) and molten salt reactors (MSRs). CEA were asked to consider whether they could host this meeting. Another possibility might be hosting by BNFL.

Other Meetings of Interest (7a)

18. A list of meetings of possible interest to the group was distributed.

Review Programme of Work (8)

18. The future programme of work of the WPPR was discussed. There are no immediate possibilities for obtaining access to experimental data other than VENUS-2 and KRITZ, which are already being progressed under the TFRPD. Possible areas for the future programme were suggested :

- A high temperature reactor (HTR) Pu physics benchmark.
- A study to define the sensitivities required by the JEFF project – this would involve determining the effect of varying different cross-sections and other nuclear parameters on the lattice and whole core physics calculations and using these to define rational limits as to the accuracy needed in the basic data. This will give a rational basis for prioritising the JEFF work more effectively.
- An investigation of the problem noted with β_{eff} in the PSI Benchmark (which was also noted in earlier WPPR studies).
- A study related to Pu management in the medium term (i.e. beyond LWR MOX, but prior to fast reactors).

ACTION : Members to put forward suggestions for discussion at WPPR-10 by mid-May 2000.

Date and Place of Next Meeting (9)

19. The tenth meeting (WPPR10) will be held in conjunction with the TFRPD3 meeting. The agreed dates are: **15-16 June 2000.**

ANNEX 1

**Ninth Meeting of NSC Working Party on
Physics of Plutonium Fuels and Innovative Fuel Cycles (WPPR9)**

**OECD/NEA, Issy-les-Moulineaux
18-19 November 1999**

LIST OF PARTICIPANTS

Andrei.Tchistiakov@wanadoo.fr

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NEA/SEN/NSC/WPPR(99)4

: Jean-marc.Hallemans@cec.eu.int

* regret not to have been able to attend

ANNEX 2

NEA/SEN/NSC/WPPR(99)3 final

ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT

Nuclear Energy Agency Nuclear Science Committee (NEANSC)

9th Meeting of the

**WORKING PARTY ON
PHYSICS OF PLUTONIUM FUELS AND INNOVATIVE FUEL CYCLES
(WPPR)**

OECD/NEA Le Saint-Germain
12 boulevard des Iles
92130 Issy les Moulineaux

18 p.m. - 19 November 1999

AGENDA

1. Introductory Remarks
 - a) Objectives of the Meeting
 - b) Introduction of Participants
2. Review and Approval of the Agenda
3. Summary of discussion on VENUS-2 Benchmark
4. BWR MOX Benchmark (Phase III)
 - a) Summary of Solutions Received
 - The Analysis of OECD/NEA Benchmark's Results for BWR Assembly with MOX Fuel (Tchistiakov, Delpech)
 - b) Presentation of Solutions by Participants
 - BWR-MOX Benchmark - contribution from Belgonucleaire (Lance)
 - Update on BWR MOX Benchmark Calculations (Gehin; Presented by Ellis, ORNL)
 - BWR MOX Benchmark Calculations by CASMO-4 with JEF-2.2 (Saji, TSI)
 - MCU Results for the BWR MOX Benchmark, (Gomin, Kalugin, Maiorov)
 - c) General Discussion/Lessons Learned
 - d) Steps for Completing the Benchmark
 - Discussion of the chapters for Volume 7 (Hesketh, Schlosser, Timm, ...)
 - Proposals for Specific Actions

5. Status of release of other benchmark experiments
 - a) PROTEUS-I/II (PSI/KWU)
 - b) ERASME (CEA)
 - c) Other experiments

6. Results from Different Projects
 - a) Status of IMF Benchmark (Paratte)
 - b) Status of ADS benchmark - Scope and Programme (Na)
 - c) Status of Benchmark on Power Distribution within Assemblies (Na)
 - d) Status report from WPEC and JEF Project (Nordborg, Jacqmin)
 - e) Proposal of a Project for the EU 5th Framework Research Programme

7. Meetings of Interest to the WPPR
 - a) Next Workshop on Advanced Reactors with Innovative Fuel Cycles (ARWIF-2001)
 - b) other meetings of interest
 - c) Proposals to NSC

8. Review Programme of Work
 - a) report to the NSC

9. Date and Place of Next Meeting

ANNEX 3

List of papers distributed as the Ninth Meeting of the NSC Working Party on Physics of Plutonium Fuels and Innovative Fuel Cycles (WPPR9) 18-19 November 1999

ANNEX 4

BWR MOX

Data to be provided by 31 January 2000 to Marc Delpech (mdelpech@cea.fr)

1. K_{eff} , peak factor, Ni(^{155,157}Gd) vs. B.U. (curves and tables with calculated burn-up).
2. 100% void case at BOL including local peaking factor, fission rate, table of void reactivity.
3. For the sensitivity analyses:
 - Ni, σ (capture, fission, (n,2n)), energy of fission and capture, flux level (all H.N. isotopes).
 - Decay period used in the depletion code (this, for the burn-up steps used for the calculation done for the benchmark).
 - PSI (CASMO 4-JEF and ENDF), CEA (APPOLLO 2-JEF), others?
4. List of questions/matrix on the methods and data:

A description of:

 - The computer program.
 - The data libraries (number of groups and energy boundaries).
 - The self-shielding models and calculations.
 - Geometric modelisation (zoning).
 - Number of zones for flux, depletion of fuels.
 - The data of fission energy release of all the isotopes.

Comments: Take the average value for each parameters without the outlier, inform these participants. Evaluation of "pure" average value in confidence interval for each participant.

Subject: **BWR MOX Benchmark**

Date: Thu, 25 Nov 1999 14:21:35 +0100

From: **Wolf Timm** <Wolf.Timm@erl19.siemens.de>

Organization: SIEMENS AG UB KWU

To: sartori <sartori@nea.fr>

CC: _____, _____, _____,

Hello

after looking into some of the newly submitted solutions of the Benchmark after the WPPR9 Meeting, we made the following observations:

- Gd-concentrations in the phase of Gd-burnout: these can be either normalised to the pellet volume (as most participants did) or to the total cell volume (as TSI did). Here is some need for clarification. My proposal is to normalise it to the pellet volume and ask TSI to renormalise their Gd-concentrations (which is just dividing by 0.015835). The spreading in the Gd-concentrations after the time of Gd-burnout is relatively large due to the small numbers, so that it is probably not very meaningful to have differences in % of a reference solution at exposures such as 10 MWd/kg. Maybe the logarithm is a better measure for intercomparison.
- Actinide concentrations : KAERI did not renormalise their concentrations (which are normalized to pellet volume). KAERI should be asked to renormalize (multiply by 0.240157). If KAERI does not respond, Mrs. Delpech/Tchistiakov should just renormalise the KAERI results on their own for the final report. We are aware that the CASMO-4 (L-Lib / ENDFB) concentrations for Cm-244 are too low which became evident when we compared the measured to calculated Cm-244 ratios for the ARIANE BWR samples (which are part of a proprietary irradiation program), therefore it is somewhat unfortunate that these CASMO values are taken as a reference for the comparisons of the nuclide concentrations. Maybe other references could be defined, what about taking the average of all solutions ?
- void reactivity: these are important parameters for BWR studies. Obviously one could just take the difference between k-inf or divide the difference by both k-inf values (or even by only one k-inf). So there is also some need for clarification. We propose: divide the difference by both k-inf's.
- 100 % void state : Even if the values for void reactivity between 80 and 100% differ appreciably among the participants, one should include them (optionally) in the Benchmark, in fact in most cases this reactivity is negative as far as I can see. Values differing much from most other solutions may be questioned. Nevertheless it is recommended (as M. Delpech proposed) to take a closer look at this special reactivity, which is however not really safety relevant under normal operating conditions. This should be done in a further sensitivity investigation (not within this Benchmark), where one could also consider the contributions of the individual isotopes and also the effect of burnup on void reactivity.

We want to inform you that we maybe contribute 2 additional solutions until end of January, one with SCALE/KENO (only BOL) and one with Monte Carlo burnup (OCTOPUS code).

ANNEX 5

Summary of Agreed Actions

BWR-MOX benchmark

1. B. Lance to investigate the possible reasons for the spread of results with WIMS and report to Tchistiakov/Delpech by 31 January 2000.
2. Participants to respond, if possible to the questionnaire prepared by Delpech/Tchistiakov and comments by W. Timm provided as Annex 4 by 31 January 2000.
3. Participants to check/correct results provided in electronic form by Tchistiakov/Delpech for correctness and provide back comments with the additional information requested by 31 January 2000

Volume VII

4. Secretariat to circulate revised Chapter 1 & 2 with WPPR9 summary
5. Participants to provide comments to K. Hesketh on the revised Chapters 1 and 2 by end of March 2000.
6. Delpech/Tchistiakov to prepare final draft tables and graphs and comments plus skeleton of chapter 3. Send it by end of March 2000 to K. Hesketh for preparation of the text.
7. K. Hesketh to prepare text and draft summary conclusions by end of May 2000 for circulations to members for comments
8. Delpech, Tchistiakov, Hesketh, Schlosser, Timm & Sartori to issue final draft of Volume VII and to distribute it for final comments to the group before WPPR-10
9. Discuss final draft and approve by WPPR10 meeting
10. Publish Volume VII by end of 2000

MOX Fuel Lattice Experiments

11. Secretariat to prepare TFRPD and WPPR common VENUS-2 benchmark report
12. M. Delpech to check if the MASURCA data could be made available
13. Pierre D'hondt to report at WPPR-10 on the status of BFS experiment at IPPE (ISTC) and possibility of use for studies within NEA projects

Next ARWIF Workshop to be held in 2001

14. M. Delpech or K. Hesketh to investigate possible hosting by CEA or BNFL.

Proposals for Future Projects

15. Members to put forward suggestions for discussion at WPPR-10 to K. Hesketh and Secretariat by mid-May 2000.