

For Official Use

NEA/SEN/NSC/WPPR(99)1



Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 04-May-1999
Dist. : 05-May-1999

English text only

**NUCLEAR ENERGY AGENCY
NUCLEAR SCIENCE COMMITTEE**

NEA/SEN/NSC/WPPR(99)1
For Official Use

Working Party on the Physics of Plutonium Recycling and Innovative Fuel Cycles

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

4-5 February 1999
OECD NEA
Issy-les-Moulineaux, France

77619

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

English text only

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

∞ Summary ∞

Introduction

The eighth meeting was opened by Chairman K. Hesketh, who first introduced the Scope and Objectives of the meeting:

- to discuss the first results from the BWR MOX benchmark based on a realistic assembly;
- to discuss the proposed VENUS-2 experimental benchmark;
- to discuss a *Review of radiotoxicity in previous WPPR benchmark analyses*;
- to discuss the recommendations of the ARWIF'98 workshop as requested by the NSC;
- to liaise with the related NSC activities.

The detailed agenda is presented in Annex 1.

The meeting was attended by 32 participants from 10 countries and two international organisations (see Annex 2).

BWR MOX benchmark

G. Schlosser gave a brief introduction reminding of the rationale behind the choice of this benchmark. The specification was prepared with a major contribution from W. Timm. Originally, several participants had asked that a specification of two to three levels of complexity be introduced to make sure that those having reduced experience with BWRs would gradually gear up to a full-fledged problem. Such a procedure might have dispersed efforts and therefore a realistic model was chosen, though somewhat simplified. The problem specified is similar to the actual design used for the Gundremmingen reactor, Germany. The upper lattice with empty rod positions above the part length fuel rods has not been considered. Under real conditions, corner rods are UO_2 rods because, due to fabrication reasons, it may not be useful to have rods with small amounts of Pu in the corners. The fuel design is intended for ~ 50 GWd/t discharge burn-up, for which a k_{inf} of ~ 1.01 is required at 30 GWd/t. A radial peaking factor within assembly of 1.2 is acceptable for 10×10 MOX designs.

M. Delpech, co-ordinator of the BWR benchmark, presented the summary of the results from about 20 solutions received. Such a large contribution had not been expected. Unlike in the previous benchmarks, this time during the first iteration there seems to have been no misinterpretation of the specification and the chairman expressed appreciation to Siemens for the good preparation work. The results submitted show a very good agreement compared to similar exercises previously carried out. The discrepancies are of the order of 1.5% for the beginning of life. This applies both to the six Monte Carlo solutions as well as to the other 14 using deterministic methods. The tables and graphs comparing the different results were prepared by Andrei Tchistiakov. Although such a good

agreement was found, some rather outlying solutions need to be revised. Discrepancies in the burn-up calculations are of the same order and are also quite satisfactory.

Participants then presented their specific results, clarifying the approaches used in calculation (details are given in the agenda).

The results were then discussed and it was agreed that complementary information needs to be provided by participants in order to make the exercise more useful. The actions agreed upon follow in the next section.

Actions on BWR MOX

The benchmark specification will remain the same as distributed; however the list of items to be submitted needs to be expanded as follows:

- Details on modelling and description of methods used need to be added (adapt a similar section found in the VENUS-2 specification for the BWR MOX needs).
- A closer look at gadolinia depletion was suggested, with the depletion of the individual Gd isotopes at:
 - more frequent intervals up to 10 GWd/t sufficient to identify the point at which k_{inf} peaks; more specifically, it is suggested to use a 1 GWd/t burn-up interval except for the first two, i.e. 0.0, 0.2, 1.0, 2.0, etc. 10.0;
 - absorption rates of ^{155}Gd and ^{157}Gd ;
 - normalisation in terms of the total absorption in the assembly;
 - specify which pins.
- Comparing detailed data for three selected pins, in particular:
 - D6 (U/Gd low power);
 - D7 (high Pu content, peaking factor);
 - E10 (average type of pin);
 - reaction rates in four energy groups (convenient and pertinent four-group structure to be defined);
 - k_{inf} versus burn-up;
 - concentration of nuclides.
- Participants should:
 - Verify that the tables distributed reproduce correctly the solutions submitted.

- Clarify the precise peaking factor quoted – specify if they powers or reaction rates (fission rates should be used in view of peaking factors).
- Submit new/revised information in a WORD 6/95 and equivalent EXCEL or text form (no higher versions).
- Confer gadolinia rods with ~10 radial sub-divisions for a good representation. Azimuthal sub-divisions may also be beneficial. Jess Gehin was asked if he could submit a sensitivity study with HELIOS varying the number of radial and azimuthal zones in the Gd pins.
- Extract a comparison of void reactivities from the data submitted and presented. The following are suggested:
 - ⇒ 0-40% void;
 - ⇒ 40-80% void;
 - ⇒ 80-100% void (i.e. void reactivity as a function of void fraction).

Note: 100% void should be taken as 100% steam density which is 0.03676 g/cm³ at 286°C. The concentrations for “saturated steam” are: $n(H) = 2.458E-3$ and $n(O) = 1.229E-3$.

- Include a table with the 40% void hot → cold 0% void reactivity swing for a better estimation of the shutdown margins.

The additional output information required for the benchmark, prepared by M. Kalugin is shown as Annex 3.

- ¹⁶O scattering data has up to 20% variation between libraries, leading to differences in Doppler coefficients due to the different in-scatter. Robert Jacqmin was asked to liaise with the WP on International Evaluation Co-operation and report at the next meeting on the reasons for this discrepancy and actions under way to resolve it.
- The presentation of the results should be reorganised:
 - A reordering of the data was requested, a possibility being to put all those results based on a common data library, or on common methods or on Monte Carlo against deterministic.

∞ DEADLINES ∞

*30 April – Issue second revision specification by Secretariat
15 September – Submission of revised results to M. Delpach
31 October – Final draft of Volume VII report distributed for final comments to the group*

Outline of Volume VII describing the benchmark (*Editor: Kevin Hesketh*)

1. Introduction (*K. Hesketh*)
2. Introduction to the specification – rationale behind the benchmark (*K. Hesketh, G. Schlosser*)
(the full specification will be presented in an Annex)
3. Summary of results (*M. Delpech, A. Tchistiakov*)
4. Conclusions with main points
5. Appendix I: Benchmark specification
6. Appendix II: Excerpts from detailed results (full results on CD-ROM)
7. List of participants

MOX fuel lattice experiments in LWRs

VENUS-2 Benchmark

The VENUS-2 experiment configuration has been released by SCK/CEN Mol including the measurements carried out. A draft specification was prepared on the basis of the information released by the NEA Secretariat. P. D'hondt set the scene of the experiment in the frame of a series of experiments carried out at different facilities around the world. The main objective concerned PWR pressure vessel dosimetry, but for defining the source, a large number of pin by pin measurements have been carried out that are useful for validating core calculations. This part of the measurements has been made available for the present benchmark study. The full data, including pressure vessel dosimetry measurements, will be integrated in the SINBAD shielding experiments database together with the VENUS 1 & 3 (UO₂) that have already been released. The benchmark study will be blind. Some participants might already have had access to the data in the frame of the original programme, and these should be identified in the benchmark report.

After discussion the following comments were provided and actions agreed on:

- A suggestion that we include an intercomparison of Doppler and void was rejected, since there were no measurements made and it would be confusing to mix an experimental comparison with a code comparison.
- A verification of the components of the plutonium vector should be carried out for the final specification.
- Definition of group numbering unconventional – reverse to avoid confusion.
- Participants should send comments on the specification by the end of February 1999.
- A final specification should be issued by the end of March.
- Participants should submit their solutions by mid-September to B.C. Na (NEA).

- The first results will be discussed at the 9th WPPR meeting (18-19 November 1999) and the experimental values will then be disclosed and compared against calculations. It was suggested that those participants who have had sight of the measured data should be identified in the results tables.
- P. D'hondt informed that he would also consider releasing data from axial measurements in VENUS-2, used for buckling determination. A 3-D VENUS-2 specification could be derived for a follow-up phase.

Other experiments

Data and results for KRITZ experiments on regular H₂O/fuel pin lattices at temperatures up to 245°C (STUDSVIK/NS-90/133), by Erik Johansson, had been released several years ago to the OECD NEA. It contains data for one KRITZ-1 experiment for a UO₂ array at four temperatures and data from three KRITZ-2 experiments, two of which for UO₂ rods and one with MOX (1.5 wt.% PuO₂, 91.5% ²³⁹Pu) measured at two temperatures. Fission rate distributions are provided. This last configuration could be useful to check moderator temperature coefficient calculations in MOX lattices. Participants have found this experiment of interest and it was decided to prepare and circulate the specification for further comments (action of the NEA Secretariat). This benchmark, it was concluded, is also a good candidate for the activities of the Task Force on Reactor-Based Plutonium Disposition.

Discussion of summary and conclusions of the ARWIF'98 workshop

The summary of ARWIF'98 (NEA/NSC/DOC(99)2) had been distributed in advance to Members of the WPPR and NSC. Kevin Hesketh introduced the summary for the different topics covered by the workshop and the panel discussion.

WPPR Members discussed the different proposals. The corresponding summary can be found in Annex 4. This summary will be submitted to the NSC.

Review of radiotoxicity in previous WPPR benchmark analyses

K. Hesketh had prepared a draft of the review of radiotoxicity in previous WPPR benchmark analyses. It aims to establish how beneficial MOX recycling is compared to other cycles. The review raised various questions for clarification which were presented to participants. Based on the studies undertaken it appears that a once-through fast reactor cycle gives a modest benefit in terms of reduced TRU activity (14-20%). Fast reactor recycle scenarios give TRU activity reductions of 15% for a burner, 9% for a converter and an increase of 1% in a breeder. The TRU activity reduction per recycle is relatively small and leads to the destruction of 37.5% in one 40-year reactor lifetime and of 50% in an 80-year lifetime. The low flow of TRU masses to repository quoted in the WPPR studies reflect indefinite recycle scenarios – the bulk of the TRU mass circulates in the fuel cycle. The once-through fast reactor scenario utilises more LWR plutonium. It is concluded that realistic fuel cycle scenarios with finite lifetimes of 40-100 years need to be considered. There is also a need to distinguish between TRU flows to the repository and TRU masses destroyed for comparisons of environmental burdens. It is found that MOX recycle scenarios may be seen as less disadvantaged compared with fast reactor scenarios. The analysis made, though restricted to the limited scenarios studied, was

found very interesting and important for communicating with the public and those carrying out more strategic studies. The paper will cover the issue in a generic way, omitting scenario considerations that are too specific. It will not give the ultimate answer, but will provide sensitivities on when you look to finite scenarios.

The resulting paper will be submitted either as a chapter in the paper in preparation for *Nuclear Technology*, or as a separate paper.

Results from different projects

- Alexander Stanculescu presented the status of Phase II of the benchmark on non-fertile fuels (IMF). Considerable progress has recently been made and participation has been expanded. Nine solutions have been provided to a heterogeneous configuration with one uranium-free rod in the centre of a 5×5 fuel subassembly. Calculations have been done for nine different configurations and seven different burn-up points. The final report will be prepared for the next meeting, scheduled for 21-22 October 1999 in Paris. In the meantime a specification for Phase III is also being prepared (one IMF fuel assembly in a UO_2 or MOX environment). A first round of discussions of the results will take place at the October meeting.
- Byung-Chan Na reported on the status of the benchmark of the Task Force on Physics Issues of Different Transmutation Concepts (TFDT). While the agreement between participants' results from Stage 1 (PWR with UO_2 fuel) and Stage 2 (PWR or FR with MOX plus minor actinides from Stage 1) is relatively good, large discrepancies have been found for Stage 3, which is concerned with partitioning and transmutation (PWR, FR, or ADS with MOX plus minor actinides from Stage 2). The final report will be prepared for the end of May 1999. In the light of the findings and conclusions, further studies are in preparation with the aim of clarifying the discrepancies and tackling a design for Stage 3 that is close to possible prototype models using liquid metal coolant and MA fuel (MA burner in a double strata fuel cycle system).
- Byung-Chan Na presented the plans for concluding Phase II of the benchmark on power distribution within assemblies (PDWA2). It is planned to prepare the final draft for the next NSC meeting under close supervision by the Task Force chairman (S. Cathalau). The WPPR concluded that if the 3-D experiments of VENUS-2 were released, a separate 3-D PDWA benchmark would not be justified.
- P. D'hondt summarised the results of the Workshop on the Physics and Fuel Performance of Reactor-Based Plutonium Disposition (NEA/NSC/DOC(98)11). The NSC endorsed setting up a separate Task Force on the Physics and Fuel Behaviour of Reactor-Based Weapons-Grade Plutonium Disposition to address this issue. The proposed scope and objectives were outlined. It was noted that this new task force and the WPPR have many basic issues in common, and that the work should be closely co-ordinated.

Update of future work programme

Following the request of the NSC to review the scope and objectives in the light of the proposals made at the ARWIF'98 workshop it was concluded that the present version adequately covers all the aspects. It was noted that the title of the WP emphasises the main activities of the first and second

phase of the work programme. It was suggested to propose to the NSC a renaming of the WP to better reflect the generalised scope and objectives it is charged with. The revised name would be “Working Party on the Physics of MOX Utilisation and Innovative Fuel Cycles” (WPPR).

The summary of the conclusions concerning the ARWIF’98 workshop to be submitted to the NSC is provided in Annex 4.

The work programme for the next few years will concentrate on:

- The completion of the BWR MOX benchmark, and issuing of the final results as Volume VII of the series.
- The issue of the final specification for the VENUS-2 benchmark. The results will be analysed and compared against the ‘blind’ experimental results. A final report will be produced (Volume VIII).
- The release of the 3-D measurements of VENUS-2 is envisaged, which could form an extension of the experimental benchmark.
- The distribution and investigation of the KRITZ-2.19 specification. More details will be discussed at the next meeting.
- The workshop *on very high converter reactors* will be organised as well as a follow up to the ARWIF’98 workshop.
- Monitoring the following activities from sub-groups:
 - Physics Issues of Different Transmutation Concepts;
 - Benchmark on Non-Fertile Fuels;
 - Power Distribution within Assemblies, Phase II.

Date and place of next meeting

It was agreed to hold the 9th Meeting of the WPPR from 18-19 November 1999 at OECD NEA Headquarters, Issy-les-Moulineaux, France.

SUMMARY OF AGREED ACTIONS

BWR MOX benchmark

- Provide comments on the specification of requested parameters of the BWR MOX benchmark. Deadline: end of March 1999 (*all*).
- Issue second revision of specification. Deadline: 30 April 1999 (*Secretariat*).
- Submit revised results to M. Delpech. Deadline: 15 September 1999 (*all*).
- Issue final draft of Volume VII; report is distributed to the group for final comments. Deadline: 31 October 1999 (*M. Delpech, A. Tchistiakov, E. Sartori*).
- Make a presentation at WPPR-9 on nuclear data. A sensitivity analysis relative to cross-section data would be useful as an addendum in Volume VII (*R. Jacqmin*).

MOX fuel lattice experiments in LWRs

- VENUS-2 benchmark:
 - Participants should send comments on specification by the end of February 1999.
 - A final specification should be issued. Deadline: end of March 1999 (*B.C. Na*).
 - Participants should submit solutions to B.C. Na (NEA). Deadline: mid September 1999.
 - The first results will be discussed at the 9th WPPR meeting (18-19 November 1999).
- Other experiments:
 - Distribute KRITZ-1/2 paper. Deadline: end of March 1999 (*E. Sartori*).

Other actions

- Draft a note for the Nuclear Science Committee summarising our discussion of the ARWIF recommendations and circulate for comments before the end of February 1999 (*K. Hesketh, E. Sartori*).
- Make progress on the paper for *Nuclear Technology* and consider including the radiotoxicity review in it or in a separate paper. Deadline: June 1999 (*K. Hesketh, E. Sartori*).
- Convene next meeting for 18-19 November 1999.

ANNEX 1

Agenda

1. Introductory remarks

- a) Objectives of the meeting (*K. Hesketh*)
- b) Introduction of participants

2. Review and approval of the agenda

3. BWR MOX benchmark (Phase III)

- a) Introduction to the benchmark study (*G. Schlosser*)
- b) Summary of solutions received (*M. Delpech, A. Tchistiakov*)
- c) Presentation of solutions by participants
 - SIEMENS results (*W. Timm*)
 - KENOREST'98 – basic information on method and results (*U. Hesse*)
 - Calculations with HELIOS (*J. Gehin*)
 - Benchmark results by the continuous energy MC burn-up code MVP-BURN (*K. Okumura*)
 - Calculational method of the NRG (Petten) results (*P. Damen*)
 - IKE methods for calculation of BWR MOX (*W. Bernnat*)
 - MCU Monte Carlo code parameters for the BWR MOX fuel assembly (*M. Kalugin, E. Gomin*)
 - MCNP-4B – methods and results (*W. Zwermann*)
 - Results obtained with HELIOS (*Y.J. Kim*)
- d) General discussion/lessons learned
- e) Steps for completing the benchmark – proposals for specific actions

4. MOX fuel lattice experiments in LWRs

- a) Presentation of VENUS-2 benchmark experiment specification (*P. D'hondt, B.C. Na*)
- b) Discussion – adoption of specification, schedule
- c) Status of release of other experiments

5. Review of radiotoxicity in previous WPPR benchmark analyses (*K. Hesketh*)

6. Results of Workshop on Advanced Reactors with Innovative Fuel Cycles (ARWIF'98)
(ARWIF'98 summary: NEA/NSC/DOC(99)2) (*K. Hesketh*)

- a) Proposals made
- b) Relevance for future work by WPPR
- c) Proposals to NSC

7. Results from different projects

- a) Status of IMF benchmark: Benchmark on non-fertile fuels, Phase II (*A. Stanculescu*)
- b) Status of benchmark of the Task Force on Physics Issues of Different Transmutation Concepts (TFDT) (*B.C. Na*)
- c) Status of benchmark on power distribution within assemblies (PDWA2) (*B.C. Na*)
- d) Relation with NSC Task Force on the Physics and Fuel Behaviour of Reactor-Based Weapons-Grade Plutonium Disposition (NEA/NSC/DOC(98)11) (*P. D'hondt*)

8. Update of future work programme

- a) Review of scope and objectives
- b) Proposal to be submitted to NSC

9. Date and place of next meeting

ANNEX 2

List of participants

BELGIUM

D'HONDT, Pierre Joseph SCK/CEN 200 Boeretang B-2400 MOL	Tel: +32 (14) 33 22 00 Fax: +32 (14) 32 15 29 Eml: pdhondt@sckcen.be
MALAMBU, Edouard Mbala SCK/CEN Fuel Research Unit Boeretang 200 B-2400 MOL	Tel: +32 (14) 33 2283 Fax: +32 (14) 32 1529 Eml: emalambu@sckcen.be
MALDAGUE, Thierry Belgonucleaire S.A. Avenue Ariane 4 B-1200 BRUXELLES	Tel: +32 (2) 774 0630 Fax: +32 (2) 774 0547 Eml: t.maldague@belgonucleaire.be

FRANCE

BOUVERET, Frederic CEA Saclay DMT/SERMA/LENR 91191 Gif sur Yvette Cedex	Tel: +33 1 6908 8155 Fax: +33 1 6908 9490 Eml: fbou@soleil.serma.cea.fr
DELPECH, Marc CEN Cadarache Bât. 230 - SPRC/LEDC F-13108 St. Paul les Durance Cedex	Tel: +33 4 42 25 28 82 Fax: +33 4 42 25 75 95 Eml: mdelpech@cea.fr
JACQMIN, Robert CEA CEN Cadarache SPRC/LEPH - Bat 230 F-13108 St.-Paul-lez-Durance	Tel: +33 (0) 4 4225 3136 Fax: +33 (0) 4 4225 7009 Eml: rjacqmin@cea.fr
MAGAT, Philippe CEA Saclay DMT/SERMA/LENR Bat. 470 F-91191 GIF/YVETTE CEDEX	Tel: Fax: +33 1 6908 9490 Eml: phi@soleil.serma.cea.fr
NICOLAS, Anne LENR/SERMA/DMT CEN/SACLAY 91191 GIF-SUR-YVETTE CEDEX	Tel: +33 (1) 69 08 59 89 Fax: +33 (1) 69 08 94 90 Eml: anne.nicolas@cea.fr
PORTA, Jacques CEA/DRN/DER/SERSI CEN Cadarache Bat. 211 F-13108 St.-Paul-lez-Durance Cedex	Tel: +33 (4) 42 25 36 31 Fax: +33 (4) 42 25 47 58 Eml: jporta@cea.fr

PUIILL, Andre
CEA/DRN/DMT
SERMA/LCA
Bat 258
CEA Saclay
91191 Gif sur Yvette Cedex

Tel: +33 (0)1 69 08 38 79
Fax: +33 (0)1 69 08 99 35
Eml: apuill@cea.fr

ROUVIERE, Gilbert
COGEMA
BCR/DSDP/SCR
1, rue des Herons
Montigny les Bretonneux
78182 St Quentin en Yvelines

Tel: +33 1 39 48 50 96
Fax: +33 1 39 48 51 63
Eml: dsdp@dial.oleane.com

TCHISTIAKOV, Andrei
29, le Tivoli, Allée des Peupliers
13090 Aix-en-Provence

Tel: +33 4 4221 0899
Fax:
Eml: Andrei.Tchistiakov@wanadoo.fr

GERMANY

BALEANU, Michael
Gesellschaft fuer Analgen und
Reaktorsicherheit (GRS)mbH
Forschungsgelaende
85748 GARCHING b. Muenchen

Tel: +49 89 3200 4530
Fax: +49 89 3200 4300
Eml: bal@grs.de

BERNNAT, Wolfgang
Universitaet Stuttgart
Institut fuer Kernenergetik
und Energiesysteme
Postfach 801140
D-70550 STUTTGART

Tel: +49 (711) 685 2118
Fax: +49 (711) 685 2010
Eml: bernnat@ike.uni-stuttgart.de

HESSE, Ulrich
Gesellschaft fuer Anlagen-
und Reaktorsicherheit
Forschungsgelaende
Postfach 1328
D-85739 GARCHING

Tel: +49 (89) 32004 502
Fax: +49 (89) 32004 491
Eml: hse@grs.de

SCHLOSSER, Gerhard
SIEMENS AG
Power Generation (KWU) Dep. NBTI
Postfach 3220
Bunsenstr. 43
D-91050 ERLANGEN

Tel: +49 (9131) 18 2453
Fax: +49 (9131) 18 4045
Eml: Gerhard.Schlosser@erl19.siemens.de

TIMM, Wolf
SIEMENS/KWU
Dept. NBTS
Postfach 3220
Freyeslebenstr. 1
D-91050 ERLANGEN

Tel: +49 (9131) 18 7559
Fax: +49 (9131) 18 5243
Eml: Wolf.Timm@erl19.siemens.de

ZWERMANN, Winfried
Gesellschaft fuer Anlagen-
u.Reaktorsicherheit (GRS) mbH
Forschungsgelaende
D-85748 GARCHING

Tel: +49 (89) 320 04 425
Fax: +49 (89) 320 04 599
Eml: zww@grs.de

KOREA (REPUBLIC OF)

KIM, Young-Jin
Manager, Reactor Physics
Korea Atomic Energy Research
Institute
P.O. Box 105, Yuseong,
Taejon 305-600

Tel: +82 (42) 868 2985
Fax: +82 (42) 861 8256
Eml: youkim@nanum.kaeri.re.kr

NEA/SEN/NSC/WPPR(99)1

JAPAN

OKUMURA, Keisuke
Reactor Analysis Laboratory
Dept. of Nuclear Energy System
JAERI
TOKAI-MURA, Naka-gun
Ibaraki-ken 319-11

Tel: +81 (282) 82 5321
Fax: +81 (282) 82 6122
Eml: okumura@mike.tokai.jaeri.go.jp

NETHERLANDS

DAMEN, Patricia M.G.
NRG
P.O. Box 25
NL-1755 ZG Petten

Tel: +31 224 56 4098
Fax: +31 224 56 3490
Eml: damen@nrg-nl.com

KLOOSTERMAN, Jan Leen
Interfaculty Reactor Institute
Delft University of Technology
Mekelweg 15
NL-2629 JB Delft

Tel: +31 15 2781191
Fax: +31 15 2786422
Eml: klooster@iri.tudelft.nl

RUSSIAN FEDERATION

GOMIN, Evgueny
RRC (Kurchatov Institute)
Dept. Physical and Technical Research
of Advanced Reactors
Kurchatov Square, 1
123182 MOSCOW

Tel: +7 095 196 9811
Fax: +7 095 196 9944
Eml: gomin@adis.vver.kiae.ru

KALUGIN, Michael A.
RRC (Kurchatov Institute)
Dept. Physical and Technical Research
of Advanced Reactors
Kurchatov Square, 1
123182 MOSCOW

Tel: +7 (095) 196 9279
Fax: +7 (095) 196 9944
Eml: kalugin@adis.vver.kiae.ru

SWITZERLAND

Alexander STANCULESCU
Paul Scherrer Institute
CH-5232 VILLIGEN PSI

Tel: +41 (56) 310 44 50
Fax: +41 (56) 310 21 99
Eml: Alexander.Stanculescu@psi.ch

UNITED KINGDOM

HESKETH, Kevin (Chairman)
British Nuclear Fuels plc
B382 Springfields Site
Salwick Preston
Lancashire PR4 0XJ

Tel: +44 1772 76 23 47
Fax: +44 1772 76 24 70
Eml: kwhl@bnfl.com

UNITED STATES OF AMERICA

ELTAWILA, Farouk
Division of Systems Technology
Office of Nuclear Regulatory
Research (RES)
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Tel: +1 (301) 415 5741
Fax: +1 (301) 415 5160
Eml: fxe@nrc.gov

GEHIN, Jess C.
Oak Ridge National Laboratory
Building 6025, MS-6363
Bethel Valley Road
P.O.Box 2008
OAK-RIDGE, Tennessee 37831-6363

Tel: +1 423 576 5093
Fax: +1 423 574 9619
Eml: gehinjc@ornl.gov

INTERNATIONAL ORGANISATIONS**CEC**

HALLEMANS, Jean-Marc
 DGXVII/C/3
 Directorate-General XVII, Energy
 TERV. A 0/18
 European Commission
 Rue de la Loi 200

Tel: +32 2 296 9404
 Fax: +32 2 295 5852
 Eml: Jean-Marc.Hallemans@bx1.dg17.cec.be

OECD NEA

NA, Byung Chan
 OECD Nuclear Energy Agency
 12 boulevard des Iles
 92130 Issy les Moulineaux

Tel: +33 1 4524 1091
 Fax: +33 1 4524 1110
 Eml: na@nea.fr

SARTORI, Enrico (Secretariat)
 OECD NEA Data Bank
 Le Seine-Saint Germain
 12 boulevard des Iles
 F-92130 ISSY-LES-MOULINEAUX

Tel: +33 (0)1 45 24 10 72
 Fax: +33 (0)1 45 24 11 10
 Eml: sartori@nea.fr

VAN DEN DURPEL, Luc
 OECD NEA
 Le Seine St. Germain
 12 boulevard des Iles
 F-92130 Issy-les-Moulineaux

Tel: +33 1 45 24 10 67
 Fax: +33 1 45 24 11 10
 Eml: vddurpel@nea.fr

Total: 32 participants from 10 countries and 2 international organisations

ANNEX 3

Additional output information for the BWR MOX benchmark

Exposure GWd/t	n.c. ^{155}Gd 10^{24} per cm^3	n.c. ^{157}Gd 10^{24} per cm^3	R_{abs} (^{155}Gd)	R_{abs} (^{157}Gd)	R_{abs} (Gd)
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Comments

1. n.c. ^{155}Gd (10^{24} per cm^3) – system average nuclides concentrations (may be averaged over three Gd pins)
2. R_{abs} (^{155}Gd) – absorption rate on the ^{155}Gd isotope in the system

$R_{abs}^{(i)}$ – relative reaction rate type x for i -th isotope in this region:

$$R_{abs}^{(1)} = \frac{\int \sum_{abs}^{(155)}(\alpha)\Phi(\alpha)d\alpha}{\int \sum_{abs}(\alpha)\Phi(\alpha)d\alpha} \quad (1)$$

three Gd pins / System

where: abs is the absorption reaction rate;

$\alpha = \left\{ \begin{matrix} \vec{r} \\ V \end{matrix} \right\}$ is the phase space co-ordinate;

$\int \sum_{abs}(\alpha)\Phi(\alpha)d\alpha$ is a total absorption rate in the system.

System

In the case when computer code uses the following normalisation:

$$R_{abs}^{(155)} = \int_{System} \Sigma_{abs}(\alpha) \Phi(\alpha) d\alpha = 1$$

then:

$$R_{abs}^{(155)} = \int_{three\ Gd\ pins} \Sigma_{abs}^{(155)}(\alpha) \Phi(\alpha) d\alpha$$

3. R_{abs} (Gd) – absorption rate for the all Gd isotopes
4. Reaction rates may be submitted in some energy groups

ANNEX 4

Report to Nuclear Science Committee from Working Party on the Physics of Plutonium Recycle and Innovative Fuel Cycles (WPPR) concerning recommendations from the ARWIF'98 workshop

OECD NEA Nuclear Science Committee Meeting
2-4 June 1999

Kevin Hesketh & Enrico Sartori
February 1999

Purpose

At the December 1999 bureau meeting of the Nuclear Science Committee, the WPPR chairman was actioned to initiate a discussion of the recommendations made in the summary of the Workshop on Advanced Reactors with Innovative Fuels (ARWIF'98), held at PSI on 21-23 October 1998 (NEA/NSC/DOC(99)2). This was put on the agenda of the eighth meeting, held in Paris on 4-5 February 1999, and this report outlines the results.

Summary of discussions

The summary of ARWIF'98 (NEA/NSC/DOC(99)2) contains a large number of recommendations, some of which are explicit and some of which are merely implied. The chairman led a discussion of all those which are pertinent to the scope of the WPPR:

- *Survey report of need for experimental facilities*

In NEA/NSC/DOC(99)2 both Alain Zaetta and Massimo Salvatores make a strong plea for a comprehensive survey report to clarify what experimental facilities in the field of reactor physics and fuel irradiation experiments will be required to address the future needs of the international R&D community. Such a report would assist with developing strategies for preserving existing facilities and with the justification of any new facilities or new investment in old ones. Salvatores notes that the CSNI is carrying out a general review under the SESAR group, one chapter of which is devoted to reactor physics, and that a need clearly exists for a co-ordinated input from the reactor physics community.

It was agreed that the WPPR should strongly support the idea for such a survey report, noting how work in its own area was crucially dependent on experimental data. Pierre D'hondt noted the SESAR activity and suggested that any contribution from the WPPR should therefore be co-ordinated, perhaps as an addendum to the SESAR report. The WPPR's contribution would include a review of facilities available for conventional MOX fuels and also for innovative fuel types, such as inert matrix fuels.

A suggested way forward is for the WPPR chairman to approach one of the members of the working group to prepare a draft review for discussion and endorsement at the next meeting

to be held on 18-19 November 1999. As a starting point, this paper could refer to an existing review (*A strategic view on nuclear data needs*, OECD NEA 1993, which includes a chapter on “resources for satisfying data needs”). The paper should also build on any progress the SESAR group has already made and attempt to avoid any duplication.

- *Workshop on very high converter reactors*

At ARWIF'98 several Japanese papers were presented on breeding PWRs and BWRs – very high conversion LWRs. This emphasises Japan's continuing commitment to establishing energy independence and would provide an alternative or complementary approach to strategic self-sufficiency to that provided by their fast reactor programme. JAERI has therefore proposed holding a workshop on this topic to facilitate information exchange.

During the WPPR's discussions, it was noted that while the topic might presently be of interest to only a small number of Member countries, the WPPR should support the proposed workshop, as it represents an important contribution to the future development of nuclear power. In particular, the WPPR could contribute by ensuring that past experience of high converter PWRs is passed on. It was the feeling of one of the most respected of the WPPR Members that there was a tendency to place too much emphasis on current perspectives of strategic requirements and that we should not forget that perspectives have changed dramatically with time. The topic of very high converter LWRs was an example where the current low priority assigned outside Asia on strategic independence could well be completely overturned in 20 years and that the proposed workshop would be a step towards keeping an option alive and fostering the flexibility aspects of the nuclear energy option.

- *Extending burn-ups for improved economy and resource utilisation*

Massimo Salvatores, in his contribution to the panel discussion at ARWIF'98, called for R&D aimed at extending discharge burn-ups for improved economy and also for developing more flexible and simpler fuel cycles. It was agreed that the WPPR should be supportive of any proposals under this heading. Extending burn-ups has particular importance for MOX economics and indeed for any system where plutonium and/or minor actinides are recycled. However, the scope for work at present was limited by the non-availability of fuel performance envelopes from fuel vendors for commercial reasons.

- *Joint experiments for irradiation and neutronics*

It was understood that this suggestion (from Salvatores) was to investigate the possibility of a new type of experiment combining the critical-type experiments with a depletion capability. It was agreed that the WPPR should support such a suggestion, as it would potentially be a valuable addition to the existing experimental database. The value of such a facility might emerge from the review of experimental facilities.

- *Innovative concepts benchmarks*

Massimo Salvatores called for benchmarks to support innovative concepts, and Henri Mouney also called for work pursuing innovative systems, specifically non-oxide fuels. The WPPR supports this suggestion and notes that the NEA is already actively pursuing this topic through its inert matrix fuels benchmark and the transmutation benchmark.

- *Innovative fuels database*

The WPPR strongly supports the setting up of a database for innovative fuels corresponding to that which already exists for conventional UO₂ and MOX fuels. The existence of such a database would stimulate further work in this area by highlighting gaps and deficiencies.

Conclusions

For the WPPR, the ARWIF'98 recommendations do not immediately point to any specific areas of work that would need to be incorporated in future work plans. However, the recommendations clearly indicate that perhaps the WPPR should pay increased attention to innovative fuel cycles in the future. The present work of the WPPR, and that of the past few years, has been focused mainly on issues associated with conventional LWRs or developments based on conventional LWR technology (such as the highly moderated PWR), a direction which has been clearly mandated by the widespread interest shown in the present BWR MOX benchmark and the earlier PWR multiple recycle benchmark. The early work of the WPPR, however, did include benchmarks for oxide and metal fuelled fast reactors, so that this would not really indicate a change of direction, but merely reflect the evolving priorities of the R&D community.

By the same token, the recommendations indicate that the WPPR should try to increase its efforts to provide "synthesis and/or decision making support" to the R&D community. One concrete possibility in the short term is given by the action that the WPPR could take in the context of the survey report of needs for experimental facilities.

Another action that could be beneficial is to charge the NEA Data Bank, under the supervision and through input from the WPPR, with the establishment of a database on "innovative fuels".