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INTERNATIONAL REACTOR PHYSICS BENCHMARK EXPERIMENTS PROJECT (IRPhEP)

Summary of Third Technical Review Meeting

23-25 October 2006
OECD Headquarters, Paris, France

English - Or. English

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Third International Reactor Physics Benchmark Experiments Project (IRPhEP)
Technical Review meeting

OECD, Paris
23 - 25 October 2006

SUMMARY

GENERAL ISSUES AND CONCERNS

The Third International Reactor Physics Experiment Evaluation Project (IRPhEP) Technical Review meeting was held in Paris, France, from 23 to 25 October 2006. A total of 27 participants from Brazil, France, Germany, Hungary, Japan, Russian Federation, Switzerland, United Kingdom, United States and one international organization (Nuclear Energy Agency) attended the meeting.

The following individuals participated in the meeting:

J. B. Briggs	Idaho National Laboratory
V. F. Dean	Consultant
A. N. Ellis	Westinghouse Electric Company
A. Hasegawa	OECD/Nuclear Energy Agency
T. Hazama	Japan Atomic Energy Agency
C. M. Hopper	Oak Ridge National Laboratory
T. Ivanova	Institut De Radioprotection Et De Sûreté Nucléaire /DSU/SEC/LERD
I. Kodeli	OECD/Nuclear Energy Agency
E. Letang	Institut De Radioprotection Et De Sûreté Nucléaire /DPEA/SEC
I. P. Matveenko	Institute of Physics and Power Engineering
R. D. McKnight	Argonne National Laboratory
T. Newton	Serco Assurance
D. W. Nigg	Idaho National Laboratory
S. Okajima	Japan Atomic Energy Agency
J. M. Paratte	Consultant
V. Rouyer	Institut De Radioprotection Et De Sûreté Nucléaire /DSU/SEC
J. L. Rowlands	Consultant
Y. Rozhikhin	Institute of Physics and Power Engineering
Y. Rugama Saez	OECD/Nuclear Energy Agency
J. M. Ruggieri	CEA/CE-CADARACHE
A. dos Santos	Instituto de Pesquisas Energéticas e Nucleares - CNEN/SP - RTF
E. Sartori	OECD/Nuclear Energy Agency
L. Scott	Idaho National Laboratory
Z. Szatmáry	Institute of Nuclear Techniques Technical University of Budapest
A. Tsibulya	Institute of Physics and Power Engineering
U. K. Wehmann	Consultant
I. Yamagishi	OECD/Nuclear Energy Agency

A copy of the final meeting agenda and a complete list of IRPhEP meeting participants are given in Annex 1 and 2, respectively.

Eleven evaluations considered for the 2007 publication were formally discussed at the meeting. Eight of the eleven evaluations will be officially published in 2006. The remaining three evaluations still require additional work but will be included in the publication in 'DRAFT' format.

A status list of evaluations scheduled for the second edition currently in progress or planned and/or archived and potentially available for evaluation is given in Annex 3.

Several important items that relate to policy and procedures that have been discussed in previous meetings are replicated in Annex 4 in order to keep them readily available to IRPhEP participants.

The Third International Reactor Physics Benchmark Experiments Project (IRPhEP) Technical Review meeting was opened with welcome and introductory remarks by Akira Hasegawa, recently designated Head of the OECD/NEA Data Bank and former member of the Nuclear Science Committee and the Data Bank Executive Group, and Enrico Sartori of the OECD/NEA. A. Hasegawa was a former member of the IRPhEP Executive group and he expressed his intent to continue to give support to this important activity. He was glad that the first Edition of the IRPhEP Handbook could be issued as scheduled in March 2006. He mentioned also that so far 220 copies of the Handbook were distributed to requesters from almost 30 countries. This indicates that there is a genuine interest in this work. He mentioned that the Government of Japan is providing to NEA funds for helping the IRPhE Project, that other countries do contribute to financing these activities within their countries. This would prove the importance of the project. Following the opening remarks, Virginia F. Dean made a presentation entitled "The Anatomy of an Evaluation".

For an IRPhEP Benchmark Experiment Evaluation the following is required:

- Detailed description of the experiment configuration (geometry, materials)
- Evaluation of the experiment (How good are the data?)
- Model of the experiment (simplified description)
- Example calculation method and result

She then explained why the result of this work is a 'Handbook'. In fact it provides a large amount of correct and useful information that is easily accessible, the data are carefully checked, and the information is well organized and clearly presented. The model in an evaluation accurately represents the experiment, and the evaluation demonstrates this. The users want to understand the experiment configuration quickly, they want to know the acceptable range of their calculated results, they want to understand how good (reliable) the information is and finally they want to use a model which is accurate and practical to calculate.

The goals of the IRPhEP Handbook are to provide ***complete information***, i.e. all relevant details of the experiment configuration, enough for the user to make an accurate model, all reasonable possible sources of uncertainty are quantified and all dimensions and material compositions of the model are given, to provide ***transparency***, i.e. the sources of everything - of geometry and material data, measurement results, uncertainties, model, and calculated results - are explained, inconsistency of data from references, missing data, neglect of possibly significant uncertainties in the evaluation or details in the model, and deficiencies of the calculations are stated; to provide ***correct data***, i.e. the evaluators and reviewers check the experimental data by comparing them with logbooks and original reports, the reviewers check that model data agree with experimental data; to provide ***clarity***, i.e. the writing is clear, concise, basic English, standard organization and format are used and definitions are given whenever they are helpful. A copy of her presentation is given in Annex 5.

APPROVAL OF EVALUATIONS

Eleven evaluations considered for the 2007 publication were formally discussed at the meeting. A summary of required actions for each evaluation discussed during the meeting is given in Appendix A. Action items are generally brief statements that are intended to remind evaluators and reviewers of detailed discussions that took place during the meeting. If participants have been assigned an action item that is unclear, Lori Scott or J. Blair Briggs should be contacted for clarification as soon as possible. *Action items for evaluations that were either "approved" or "approved pending completion of action items" at the meeting should be completed, verified by internal and external reviewers (and subgroup members if one was formed), and an electronic copy of the revised evaluation (in WORD format) should be submitted to Blair Briggs (j.briggs@inl.gov) by the specified completion date.*

The group briefly discussed the evaluation guide, Version 8.9. Blair Briggs will review the guide to verify if any revisions should be made this year. However, the general consensus is that the guide should remain fixed unless major deficiencies are identified. Participants will be asked to review the guide, if revision is deemed necessary, prior to publication. Clarifications to the guide or interpretive guidance will be maintained on the Internet until revision of the guide becomes necessary.

The second edition of the Handbook is scheduled for publication by 15 March 2007. All evaluations approved as official or draft evaluations were assigned due dates. The planned publication schedule overlaps scheduled activities of the International Criticality Safety Benchmark Evaluation Project (ICSBEP). Therefore, it is essential that evaluators submit their evaluations by these given due dates or they may not be processed in time to be included in the 2007 Edition of the Handbook.

Authors were reminded that references and original data, if available, can be scanned and included on the publication DVD and linked to their evaluation.

Authors were also reminded that keywords used in the evaluation should be carefully considered and are intended to be a useful summary of key elements which can be found within the evaluation. Obvious and/or extraneous keywords should be avoided.

As suggested, Lori Scott will set up an evaluation format template for those who want to use it. While this template may be useful to evaluators for specific page setup-type guidance, it is not a requirement that it be used. Lori Scott is very willing and responsible for ensuring that all evaluations adhere to the standard format. Evaluators are encouraged to continue concentrating on the actual content of the evaluation and allow Lori Scott to concentrate on the format and presentation of the evaluation. Evaluators are reminded that the template used by them and/or Lori Scott contains certain specific 'style' macros. Use of independent 'styles', such as auto table/figure numbering, auto header numbering, auto spacing, etc., should be avoided. These independent styles typically conflict with the 'projects' styles and will likely be removed, in order to ensure consistent formatting/presentation between evaluations.

It was also suggested that for future meetings independent reviewers prepare and bring a list of major unresolved actions for each evaluation. Reviewers can provide the list to Lori Scott to ensure inclusion in the action list. This request will hopefully help ensure that all actions are accounted for.

With regard to identifiers, it was decided that if data are provide in Section 1 for any particular measurement type, the measurement type should be included in the identifier. If the data have not yet been evaluated, it should be so stated in the appropriate sections of the evaluation. Information from partial evaluation can be included in Section 2; however it should be noted at the beginning of each Section that the data have not yet been **fully** evaluated. Benchmark model specifications are ONLY provided if the data have been fully evaluated and deemed to be acceptable for use as a benchmark. Modeling information

and calculational results for unacceptable data may be preserved in an appendix. Identifiers included for unevaluated data should be italicized. This information will be clarified in the format guide as part of the identifier explanation.

IRPhEP evaluators tend to go to great lengths to quantify the effect of uncertainty in critical configurations and provide the basis for those uncertainties. However, for other measurement types the trend seems to be to simply quote or reference a value, either estimated by the experimenter or evaluator or published in an older document. It was emphasized throughout the meeting that the basis for these estimates should be provided and discussed. Many users of IRPhEP data have never made a measurement and many have little experience analyzing these types of measurements. The future may not hold many opportunities for the next generation of reactor physicists to perform such measurements. The IRPhEP is at a unique moment in time. Those whose careers have offered them vast experience in this field have the opportunity to pass their experience, both analytical and experimental, on to those who will follow for the next several decades. The IRPhEP is the **present experts'** legacy, one that will either live for decades or diminish in time, depending on how effectively this work is completed. Evaluators are encouraged to spend the extra days or weeks that are necessary to impart their knowledge of these benchmarks in a clear and complete manner. The effects of uncertainty in geometry and materials may be relatively insignificant compared to effects of uncertainty in measurement techniques, but this fact may not be evident to everyone. It is important to at least state that based on the experience of the evaluator, the effects of these types of uncertainties are insignificant along with a short explanation. It would be even more helpful if this fact could be demonstrated in at least a few selected cases.

DISCUSSION AND CONCLUSIONS

When the IRPhEP technical review group meets next, it will have been approximately one year since its last meeting. This will be the only chance for the group to review and approve evaluations for publication (draft or formal). *It is important that thorough internal and independent reviews be completed prior to the meeting, so the evaluations brought before the group can be approved with a minimal amount of rework.*

In order to avoid an unmanageable number of independent reviews just prior to distribution for the next meeting, evaluators and internal reviewers should complete their work as soon as possible and send their evaluations to the INL (or directly to the independent reviewer if prior arrangements have been made) for independent review. The last possible date for which independent reviews can be initiated, with a reasonable chance for completion and resolution of comments in time for the next meeting, is August 31, 2007. Independent reviews will be performed on a first received first reviewed basis. If more evaluations are received on August 31, 2007 than can be thoroughly reviewed, the later evaluations will be deferred until the next meeting. Evaluators and reviewers are encouraged to make every effort to complete their work in a timely manner and submit ***only*** evaluations that have successfully undergone ***thorough internal review***.

Evaluations in progress or planned and or archived and potentially available

The status of other evaluations in progress was briefly reviewed and a list of other evaluations that should be carried out in the future in an order to be determined by the different National priorities was presented. Some new sets of reports describing experiments from the past were scanned and are available in electronic form for future evaluations. A list of all these experiments together with those scheduled for the next publication are presented in Annex 3.

S. Okajima presented the status of the evaluations on VHTRC and the TCA experiments. The details are provided as Annex 6.

Adimir dos Santos from IPEN-CNEN/São Paulo – Brazil presented the "Potential Reactor Physics Experiments Performed at the IPEN/MB-01 Reactor Facility for the IRPhE Project. These include:

a) Effective kinetic parameters (β_{eff},β_{eff}/Λ, Λ, relative abundances and decay constants)
b) Power and fission density distribution
c) Spectral Indices ($^{28}\rho$, $^{25}\delta$, and $^{28}\delta$)
d) Buckling and extrapolation length
e) Reactivity measurements, reactivity coefficient
f) Reaction-rate distributions, and
g) Others

He presented the following possible schedule for contributions to IRPhEP:

2007: Effective kinetic parameters (β_{eff},β_{eff}/Λ, Λ)
2008: Effective kinetic parameters (Relative Abundances, Decay Constants and Reactivities)
2009: Power and fission density distributions, and buckling and extrapolation length
2010: Spectral Indices ($^{28}\rho$, $^{25}\delta$, and $^{28}\delta$)

A copy of the full presentation is enclosed as Annex 7.

Other experimental data offered for the IRPhEP

T. Hazama reported on the evaluation plan of JOYO MK-I depletion data. Participants agreed that this would be most valuable data to include into IRPhEP. Details of the plan are provided as Annex 8.

The final report on ISTC Project # 116-096 entitled, "Development of Calculation and Methodical Technology of the Verification of Nuclear Data Bases to be Used in Calculations of Neutron-Physical Characteristics and in the Analysis of Nuclear Safety of Nuclear Power Plants and Nuclear Conversion Technologies" was distributed to IRPhEP participants. This report makes mention of numerous experiments that could be of interest to the IRPhEP.

D. Nigg mentioned that the PBF Facility Fast Kinetics Experiments are candidates for inclusion into IRPhEP.

IRPhEP and WPRS

E. Sartori reported that following the decision taken at the NSC meeting in June 2006, the Working Party on Scientific Issues of Reactor Systems (WPRS) would cover the following three major work areas:

1. Experiments;
2. Reactor and fuel analysis;
3. Radiation transport & dosimetry

With this reorganization, the IRPhEP is part of the area on Experiments and the results from the IRPhEP activities should be reported to the WPRS. The next meeting of the WPRS is scheduled for 31 January 2007

SAGEP-FR code systems

Following the discussion held at the previous meeting concerning sensitivity and uncertainty analyses and the needs for it in the IRPhEP evaluations, M. Ishikawa had promised to investigate the possibility of releasing a code system carrying out such analyses that had been developed over many years at the former PNC and JNC, now part of JAEA. This code system containing several relevant modules was released in February 2006 by JAEA. As part of the documentation was in the Japanese language, an effort was made since to translate the reports into the English language. This work is nearing completion and the manuals are convenient to use as they are computer based and facilitate the navigation through it and the searching of the different parameters required for modeling the benchmarks. This work will be completed during the first quarter of 2007.

Official release of data

Evaluators who are providing data that are not all available in the open literature and who are independent of the organization to which the data belongs shall obtain permission from that organization prior to submitting the data to the IRPhEP. Under such circumstances, evaluators should provide the NEA with evidence of entitlement. All evaluators are asked to submit an e-mail or letter stating that the data contained in their evaluation(s) have been officially released and that the IRPhEP is permitted to publish their evaluation(s). This letter (or e-mail) should be submitted to Enrico Sartori by 12 January 2007.

IRPhEP Guidelines and ANSI Standards

At the ANS Standards meeting held in Reno, Nevada on 3 June 2006, the guide for acquisition and documentation of reference power reactor physics measurements for nuclear analysis verification (ANSI/ANS-19.4) and the requirements for reference reactor physics measurements (ANSI/ANS-19.5), were up for renewal. It was agreed that ANS-19 (reactor physics) members would review the guidelines given in the IRPhE Handbook and comment as to whether 19.4 and 19.5 should be revised accordingly by taking advantage of the experience and expertise from the IRPhEP.

Next Meeting and Venue

The next IRPhEP technical review meeting will be hosted by the University of Pisa, Italy, from 22-24 October 2007. Only evaluations that have successfully undergone both internal and independent reviews will be reviewed by the Technical Review Group. Details of the meeting will be provided at a later date.

Annex 1

International Reactor Physics Benchmark Experiments Project
Technical Review Meeting

23 – 25 October 2006

OECD Monaco Annex, 2 rue Conseiller Collignon, 75016 Paris, France

Final Agenda

Monday, 23 October 2006

SESSION I: GENERAL ISSUES AND CONCERNS

- Welcome [Akira Hasegawa / Enrico Sartori]
- Introduction of Participants [All]
- Comments from INL [J. Blair Briggs]
- Administrative Items & Publication Schedule [Lori Scott]
- Anatomy of an Evaluation [V. F. Dean]
- Comments / Discussions [All]

SESSION II: APPROVAL OF EVALUATIONS

HTR10-GCR-RESR-001 CRIT-REAC	Evaluation of the Initial Critical Configuration for the HTR-10 Pebble Bed Reactor	J. Blair Briggs for William K. Terry

SESSION III: APPROVAL OF EVALUATIONS (continued)

BFS1-FUND-EXP-001 CRIT-SPEC-REAC-KIN-RRATE (MIX-MISC-MIXED-001)	Experimental Program Performed at the BFS-97, -99, -101 Assemblies - Critical Experiments with Heterogeneous Compositions of Plutonium, Depleted Uranium Dioxide and Polyethylene	Evgeniy Rozhikhin Anatoly Tsibulya
BFS1-FUND-EXP-002 SPEC-REAC (MIX-MISC-FAST-001)	Experimental Program Performed at the BFS-42 Assembly - k-infinity Experiments for 238U in Fast Neutron Spectra: Measurements with Plutonium Mixed with Depleted Uranium Dioxide and Polyethylene	Evgeniy Rozhikhin Anatoly Tsibulya

SESSION IV: APPROVAL OF EVALUATIONS (continued)

BFS1-FUND-EXP-003 SPEC	Experimental Program Performed at the BFS-57, -59 Assemblies - Critical Experiments with Heterogeneous Compositions of Enriched Uranium or Plutonium, Depleted Uranium Dioxide and Polyethylene	Evgeniy Rozhikhin Anatoly Tsibulya
FS2-FUND-EXP-001 (MIX-MISC-FAST-001)	Experimental Program Performed at the BFS-31 Assemblies - k-infinity Experiments for 238U in Fast Neutron Spectra: Measurements with Plutonium Mixed with Depleted Uranium Dioxide	Evgeniy Rozhikhin Anatoly Tsibulya

SESSION V: APPROVAL OF EVALUATIONS (continued)

IPEN(MB01)-LWR-RESR-001 CRIT-COEF	The Isothermal Experiment at the IPEN/MB01 Reactor	Adimir dos Santos

Tuesday, 24 October 2006

SESSION VI: APPROVAL OF EVALUATIONS (continued)

ZEBRA-LMFR-EXP-001 CRIT-SPEC-REAC-RRATE	Fast Critical Experiments in Plate and Pin Geometry Form. The ZEBRA CADENZA Cores, Assemblies 22, 23, 24 and 25	John Rowlands

SESSION VII: APPROVAL OF EVALUATIONS (continued)

EBRA-LMFR-EXP-002 CRIT-SPEC-REAC-RRATE	The ZEBRA MOZART Programme Part 1. MZA and MZB, ZEBRA Assemblies 11 and 12	John Rowlands

SESSION VIII: APPROVAL OF EVALUATIONS (continued)

ZEBRA-LMFR-RESR-003 CRIT-REAC-RRATE	The ZEBRA MOZART Programme Part 2. MZC and the Control Rod Studies ZEBRA Assembly 12	John Rowlands

SESSION IX: APPROVAL OF EVALUATIONS (continued)

CROCUS-LWR-RESR-001 CRIT-REAC-KIN	Kinetic Parameters and Reactivity Effect Experiments in CROCUS	J. M. Paratte

Wednesday, 25 October 2006

SESSION X: APPROVAL OF EVALUATIONS (continued)

VENUS-PWR-RESR-003	VENUS-3 PWR UO_2 Core 3-Dimensional Benchmark Experiment	Bok Ja Moon (Unavailable)

SESSION XI: APPROVAL OF EVALUATIONS (continued)

VENUS-PWR-RESR-001	VENUS-1 PWR Core -- 2-Dimensional Benchmark Experiment	Bok Ja Moon (Unavailable)

SESSION XII: DISCUSSION AND CONCLUSIONS

Evaluations planned for 2007 and following years / short presentations	All
Evaluation plan of JOYO MK-I depletion data	Taira Hazama
Reactor Physics Experiments in the IPEN/MB-01 Research Reactor Facility	Adimir Dos Santos
Reporting to WPRS, NCS and Data Bank Executive Group	Enrico Sartori
Next IRPhEP Meeting	All

Annex 2

International Reactor Physics Benchmark Experiments Project

List of

Members and Technical Review Group Participants

3rd Technical Review Mtg. Paris 23-25.X.2006)

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* regrets not to have been able to attend

Annex 3

STATUS OF EVALUATIONS

SCHEDULED FOR THE SECOND EDITION CURRENTLY IN PROGRESS OR PLANNED AND/OR ARCHIVED AND POTENTIALLY AVAILABLE FOR EVALUATION

Evaluations Scheduled for the 2007 Edition

- BFS1-FUND-EXP-001 CRIT-SPEC-REAC-KIN-RRATE BFS-97, -99, -101 Assemblies: Experimental Program On Critical Assemblies with Heterogeneous Compositions of Plutonium, Depleted-Uranium Dioxide, and Polyethylene, Draft, (2006-10-11)
- BFS1-FUND-EXP-002 SPEC-REAC-RRATE, - Experimental Program Performed at the BFS-42 Assembly - K-infinity Experiments for U-238 in Fast Neutron Spectra: Measurements with Plutonium Mixed with Depleted Uranium Dioxide and Polyethylene, Draft, (2006-10-11)
- BFS2-FUND-EXP-001 SPEC-REAC, - Experimental Program Performed at the BFS-31 Assemblies – K-infinity Experiments for U-238 in Fast Neutron Spectra: Measurements with Plutonium Mixed with Depleted Uranium Dioxide, Draft, (2006-10-11)
- CROCUS-LWR-RESR-001 CRIT-REAC-KIN, - Benchmark on Kinetic Parameters and Reactivity Effects in CROCUS, DRAFT (2006-10-23)
- HTTR-10-GCR-RESR-001-REAC-COEF-RRATE, - Evaluation of the Initial Critical Configuration of the HTR-10 Pebble-bed Reactor
- IPEN(MB01)-LWR-RESR-001 CRIT-COEF, - Reactor Physics Benchmark Experiments in the IPEN/MB-01 REACTOR Revision 3, (2006-10-3)
- ZEBRA-LMFR-EXP-001 CRIT-SPEC-REAC-RRATE, - Fast Critical Experiments in Plate and Pin Geometry form. the ZEBRA CADENZA Cores, Assemblies 22, 23, 24 and 25, Draft, (2006-11-22)
- ZEBRA-LMFR-EXP-002 CRIT-REAC-RRATE, - The ZEBRA MOZART Programme. Part 1. MZA and MZB ZEBRA Assemblies 11 and 12, Draft, (2006-10-15)
- ZEBRA-LMFR-EXP-003 CRIT-REAC-RRATE, - The ZEBRA MOZART Programme. Part 2. MZC and the Control Rod Studies ZEBRA Assembly 12/4 Draft, (2006-10-15)
- ZPPR-LMFR-RESR-001 CRIT-SPEC-REAC-RRATE - JNC Large fast reactor experiment ZPPR-10A in JUPITER (2005-10-12)
- ZR6- VVER-EXP-001 CRIT-BUCK-SPEC-REAC-COEF-RRATE, The VVER Experiments: Regular and Perturbed Hexagonal Lattices of Low-Enriched UO_2 Fuel Rods In Light Water, (2006-10-26)

Evaluations to be published again as drafts

- VENUS-PWR-EXP-001 BUCK-RRATE-POWDIS - VENUS-1 PWR UO2 Core 2-Dimensional Benchmark Experiment (2005-05-29)
- VENUS-PWR-EXP-003 RRATE-POWDIS - VENUS-3 PWR UO2 Core 3-Dimensional Benchmark Experiment (2005-05-29)
- ZPPR-LMFR-RESR-001 CRIT-SPEC-REAC-RRATE - JNC Large fast reactor experiment ZPPR-10A in JUPITER (2005-06-30),

Evaluations, in progress, requiring further work of final review

- VENUS-PWR-EXP-002 CRIT-BUCK-RRATE-POWDIS - VENUS-2 PWR MOX Core Measurements (VENUS-2) (2003-06-12)
- ZPR-LMFR-RESR-001 CRIT-BUCK-SPEC-REAC-RRATE (MIX-COMP-FAST-001) - ZPR-6 Assembly 7: A Cylindrical Assembly With Mixed (Pu,U)-Oxide Fuel and Sodium with a Thick Depleted-Uranium Reflector
- ZPR-LMFR-RESR-002 CRIT-SPEC-REAC - ZPR-6 Assembly 7 with High Pu-240: A Cylindrical Assembly With Mixed (Pu,U)-Oxide Fuel and Sodium with a Thick Depleted-Uranium Reflector
- KRITZ-PWR-EXP-001 CRIT-BUCK-REAC-RRATE - KRITZ-2:19 Experiment on Regular H2O/Fuel Pin Lattices with Mixed Oxide Fuel at Temperatures up to 245°C ((2005-11-21)
- PROTEUS-GCR-EXP-001 CRIT-SPEC-REAC-RRATE - Shut-down Rod Worths in LEU-HTR Configurations
- BFS1-FUND-EXP-003 SPEC - Experimental Program Performed at the BFS-57, -59 Assemblies - Critical Experiments with Heterogeneous Compositions of Enriched Uranium or Plutonium, Depleted Uranium Dioxide and Polyethylene

Evaluations requiring considerable more work before approval

- STEK-LMFR-EXP-001 CRIT-SPEC-REAC-RRATE (STEK) (2004-09-12)
- VENUS-PWR-EXP-004 CRIT-BUCK-REAC-KIN-RRATE - Experimental Study of the VENUS Configuration No. 7
- VHTRC-GCR-EXP-001 CRIT-COEF - VHTRC Temperature Coefficient Benchmark
- STEK-LMFR-EXP-001 CRIT-SPEC-REAC-RRATE - Reactivity Worth Measurements and Other Experiments in the Critical Facility STEK
- SNEAK-LMFR-EXP-001 CRIT-SPEC-REAC-RRATE SNEAK-7A&B Pu-fuelled fast critical assemblies in the Karlsruhe Fast Critical Facility
- SNEAK-LMFR-EXP-002 CRIT-SPEC-REAC-RRATE - SNEAK 9C Experimental Series of SNR 300 Specific Criticals
- TCA-LWR-EXP-001 CRIT-COEF - TER-2 in LWR UO_2 with Soluble Poisons
- VENUS-PWR-EXP-005 CRIT-SPEC-POWDIS - Experimental Study of the VENUS Configuration No. 9
- VENUS-PWR-EXP-006 CRIT-BUCK-SPEC-REAC-POWDIS - Experimental Study of the VENUS Configuration No. 17
- ASTRA-HTGR-EXP-001-CRIT-REAC-RRATE - ASTRA Critical Facility Experiments
- ZEBRA-RESR-EXP-001-CRIT-SPEC-RRATE - K-Infinity Experiments In Fast/Intermediate Neutron Spectra for Various Fissile Materials - ZEBRA Core 8

Experiments proposed for inclusion in IRPhE

- RRR/SEG-LMFR-EXP-001- CRIT-SPEC-REAC-RRATE Sample Reactivity Measurements in the Rossendorf SEG Configurations
- B&WSSCR-PWR-EXP-001 CRIT-SPEC-REAC B&W-SSCR, Spectral Shift Reactor Lattice Experiments
- BERENICE - Investigations of the delayed neutron fraction in MASURCA
- CREOLE - Temperature coefficient of UOX and MOX up to 300°C in EOLE
- RACINE - Fast reactor experiments in support of Phenix
- ZPPR-9 experiment: 600 MWe class, two-region homogeneous clean core: one feature is the measurement of the sample Doppler reactivity in JUPITER
- ZPPR-13A: 650 MWe class, radially-heterogeneous clean core in JUPITER: very weak core-coupling - difficult from the reactor physics viewpoint
- ZPPR-17A: 650 MWe class, axially-heterogeneous clean core in JUPITER: medium characteristics between homogeneous and radially-heterogeneous core from core-coupling
- ZPPR-19B: 1000 MWe class, two-region homogeneous core with enriched uranium in the outer core region in JUPITER: the largest FBR mockup core in the history
- AVR HTR Experiments
- OECD/DRAGON GCR Experiments
- IPEN - Effective kinetic parameters (βeff,βeff/Λ, Λ)
- IPEN - Effective kinetic parameters (Relative Abundances, Decay Constants and Reactivities)
- IPEN - Power and fission density distributions, and Buckling and extrapolation length
- IPEN - Spectral Indices ($^{28}\rho$, $^{25}\delta$, and $^{28}\delta$), etc.
- JAEA - Burn-up reactivity measured in 50MWth power ascension test, 50MWth 1st and 2nd cycles, and 75MWth 1st-4th cycles (Measured in 1978-1981. Several assemblies were replaced between cycles.)

Primary Documentation Archives (October 2006)

- **IRPHE/B&W-SS-LATTICE**, Spectral Shift Reactor Lattice Experiments
- **IRPHE-JAPAN**, Reactor Physics Experiments carried out in Japan
- **IRPHE/JOYO MK-II**, JOYO MK-II core management and characteristics database
- **IRPhE/RRR-SEG**, Reactor Physics Experiments from Fast-Thermal Coupled Facility
- **IRPHE-SNEAK**, KFK SNEAK Fast Reactor Experiments, Primary Documentation
- **IRPhE/STEK**, Reactor Physics Experiments from Fast-Thermal Coupled Facility
- **IRPHE-ZEBRA**, AEEW Fast Reactor Experiments, Primary Documentation
- **IRPHE-DRAGON-DPR**, OECD High Temperature Reactor Dragon Project, Primary Documents
- **IRPHE-ARCH-01**, Archive of HTR Primary Documents
- **IRPHE/AVR**, High Temperature Reactor Experience, Archival Documentation
- **IRPHE-KNK-II-ARCHIVE**, KNK-II fast reactor documents, power history and measured parameters
- **IRPhE/BERENICE**, effective delayed neutron fraction measurements
- **IRPhE-TAPIRO-ARCHIVE**, Fast neutron source reactor primary documents reactor physics experiments

Annex 4

Policy and Procedure Issues from Previous Meetings

- A discussion was held on sensitivity / uncertainty analysis in order to gain an appreciation for the amount of work that is required and an understanding on the level to which the group should work. Ideally, each measured parameter that is proposed as a benchmark should include a benchmark value for that parameter (i.e., the value that one should expect to obtain after incorporation of any biases that are introduced due to methods or modeling simplifications) and an associated uncertainty. The uncertainty should be a "best estimate" where possible; however, in the absence of sufficient supporting data, bounding values should be used. All uncertainties should be adjusted to 1σ values. Implementation was addressed on a case-by-case basis until the group comes to a better consensus on what can be achieved for the various types of measurements.

- The group was reminded that summaries and status forms to evaluations should be provided for each evaluation by evaluators. Summaries should be reviewed and approved by both internal and independent reviewers. Status forms simply need to be completed by the evaluators. Summary and Status forms will be linked, rather than included in the actual evaluation.

- The group agreed that data not being evaluated should still be provided in Section 1 for preservation purposes. However, models for data that are not evaluated should not be included in Section 3 and sample results should not be included in Section 4. Models and results can be provided in an appendix subsequent to Appendix A, again for preservation purposes.

- When certain sections of an evaluation are reviewed by different independent reviewers (i.e., reviewers do not review the entire evaluation, but limit their review to areas of specialization or previously published ICSBEP evaluations for which the critical configuration was most often reviewed independently of the other measurement types), the cover page will denote which measurement types were reviewed by each reviewer.

- It should be noted on figures contained in the evaluations if they were drawn to scale or not to scale.

- The group was reminded that results that are reported in Section 4 should be given in the form of 100(C-E)/C. Absolute results should also be reported.

- Personal communications with experimenters should be documented as footnotes within evaluations.

- The group was reminded that, for each measurement type, conclusions of acceptability should be included in the appropriate subsections of Section 2 and summarized in the appropriate subsection of Section 1.

- The preferred standard format for numbering tables and figures will be to number sequentially within one of the four major sections (e.g., For Section 2.0 tables/figures, label as Table/Figure 2.1, 2.2, etc. (it is also acceptable to use addition levels of numbering – 2.1.a, 2.1.b, etc., if necessary). Tables/figures should be numbered consistently within each evaluation.

- The meaning of compilation and evaluation and what work needs to be carried out for approval at the review meetings was clarified. The different sections for each experiment will contain:

  - Description (Section 1)
  - Evaluation (Section 2) – Evaluation includes sensitivity/uncertainty analysis of measured parameters described previously. Engineering judgement should be used to estimated or bound uncertainties that were not specified. Uncertainties in all measured parameters should be address at an appropriate level of detail.
  - Benchmark specification (Section 3)
  - Sample results (Section 4)
  - An Appendix with the code input as example of the benchmark
  - Other information that is produced (e.g. comparison between different evaluators of code results not measured) should be provide in an additional appendices.

  Each of the evaluation section or chapter requires conclusions. Conclusions should also be summarized in Sections 1.0 and 1.X.1

- Specific tasks to be carried out have been discussed again and agreed on relative to Quality Assurance. Each experiment evaluation must undergo a thorough internal review by the evaluator's organization. The internal reviewers must verify:

  - The accuracy of the descriptive information given in the evaluation by comparison with the original documentation (published and unpublished)
  - That the benchmark specification can be derived from the descriptive information given in the evaluation
  - The completeness of the benchmark specification (Generally requires setting up a model using only the information given in Section 3.)
  - The results and conclusions
  - Adherence to format

  In addition, each experiment must undergo and independent peer review by another working group member at a different facility. Starting with the evaluator's submittal in the appropriate format, the independent peer reviewers must verify:

  - That the benchmark specification can be derived from the descriptive information given in the evaluation
  - The completeness of the benchmark specification
  - The results and conclusions
  - Adherence to format

  A third review by the Technical Review Group verifies that the benchmark specification and the conclusions are adequately supported.

- The co-ordination with ICSBEP was addressed. This was found of particular importance because of the common interest in the critical configurations. It was unanimously agreed that

  - any activity that would lead to duplication of effort would be avoided, because of cost in resources, and the need of coherence and consistency between the two projects.
  - the critical configuration description and evaluation, if included in ICSBEP, it will be adopted as is for IRPhE, and made accessible by a hyperlink to the ICSBEP file copied

into the IRPhE database. Feedback from IRPhE must be reported to ICSBEP, reviewed by them and if adopted, the corresponding file will be copied to IRPhE.

- the critical configuration and evaluation that is carried out as the first chapter of IRPhE if of interest to ICSBEP, if found appropriate, will simply be copied as is with all the other chapters into ICSBEP, where it can be accessed via a hyperlink.

- The group was reminded that an electronic IRPhE listserver or evaluator/reviewer forum was established at the NEA Data Bank that should facilitate the communication between the different parties involved in the project and to keep an electronically ordered archive of the discussion.

- It was reemphasized that the INL can offer graphic arts assistance for anyone who would like assistance. All figures will normally need additional work by the INL graphic arts department in order to ensure compatibility.

Annex 5

International Reactor Physics Experiments Evaluation Project
Technical Review Meeting, October 23-25, 2006

Anatomy of a Benchmark Experiment Evaluation

(Why is this a '***Handbook***'?)

by Virginia A. F. Dean, PhD, nuclear engineering

ICSBEP: International Criticality Safety Benchmark Evaluation Project

- Provides models of critical experiments.
- The models are used to validate calculation methods for Criticality Safety (k_{eff}<1 requirement for configurations of fissile material in storage or processing).
- **The model must accurately represent the experiment, and the evaluation must show this.**

Benchmark Experiment Evaluation

- Detailed description of the experiment configuration (geometry, materials)
- Evaluation of the experiment (How good are the data?)
- Model of the experiment (simplified description)
- Example calculation method and result

What is a Handbook?

- A handbook provides a large amount of correct and useful information that is easily accessible.
- Therefore the data are carefully checked, and the information is well organized and clearly presented.

Why are these IRPhEP experiment documents in a Handbook?

- Because they provide a large amount of useful information.
- Because the data are correct.
- Because the data are easily accessible:
  - Well organized
  - Clearly presented
- Because the model accurately represents the experiment, and the evaluation demonstrates this.

IRPhEP Handbook - Goals

Useful Information:

- Users want to understand the experiment configuration quickly.
- They want to know the acceptable range of their calculated results.
- They want to understand how good (reliable) the information is.
- They want to quickly calculate the model.

IRPhEP Handbook - Goals
(cont'd)

Complete Information:

- All relevant details of the experiment configuration are in Section 1, enough for the user to make a very detailed model.
- All reasonable possible sources of uncertainty are quantified in Section 2.
- All dimensions and material compositions of the model are given in Section 3.

IRPhEP Handbook - Goals
(cont'd)

Transparency:

- Sources of everything - of geometry and material data, measurement results, uncertainties, model, and calculated results - are explained.
- Inconsistency of data from references, missing data, neglect of possibly significant uncertainties in the evaluation or details in the model, and deficiencies of the calculations are stated.

IRPhEP Handbook - Goals
(cont'd)

Correct data:

- Evaluators and reviewers check the experimental data by comparing them with logbooks and original reports.
- Reviewers check that model data agree with experimental data.

IRPhEP Handbook - Goals
(cont'd)

Clarity:

- Writing is clear, concise, basic English.
- Standard organization and format are used.
- Definitions are given whenever they are helpful.

IRPhEP Experiment Evaluation

- Section 1 - Detailed experiment description
- Section 2 - Evaluation of the experiment
- Section 3 - ***Benchmark model***
- Section 4 - Sample calculations

IRPhEP Evaluation - Section 1

Detailed Experiment Description

- Section 1 only describes the experiment, experimental data, and sources of experimental data.
- Except perhaps in the overview, no evaluative statements or discussion of models or calculated results are given.
- Only facts are given, like a news report by a good journalist.

IRPhEP Evaluation - Section 1
(cont'd)

Experimental data (parameter values, uncertainties, and measurement methods)

1.X.1 - Overview (introduction)

1.X.2 - Geometry,
Measurement of the *parameter of interest*
(k_{eff}, σ_{28}/σ_{25}, B^2, ρ, etc)

1.X.3 - Materials - mass or density; composition

1.X.4 - Temperature

1.X.5 - Other relevant information

IRPhEP Evaluation - Section 2
Evaluation of Experimental Data

Section 2 answers these questions about the experimental data in Section 1:

- Is the information sufficient?
- Are the data well known?
- How do uncertainties of data affect the *parameter of interest* ?

IRPhEP Evaluation - Section 2

(cont'd)

Effects of Uncertainties of Experimental Data on the *Uncertainty of the Parameter of Interest*

- Estimate 'standard uncertainties' (approximate standard deviations) of measured dimensions, compositions, etc.
- Explain sources of the standard uncertainty values. How were uncertainty values obtained?
- Give measured or calculated sensitivities of the *parameter of interest* to the measured data.
- Combine effects of standard uncertainties to get the *uncertainty of the parameter of interest*.

IRPhEP Evaluation - Section 3 Benchmark Model

- What are the differences between the benchmark model and the experiment?
- How do model simplifications affect the value of the parameter of interest?
- Describe the benchmark model.

IRPhEP Evaluation - Section 3

(cont'd)

Benchmark Model Consistency Requirement

The benchmark model must be consistent with the experiment: The arrangement of materials in the model is the same as in the experiment.

Then the neutron spectrum of a correct calculation is the same as the neutron spectrum of the experiment, and the effect of each cross section on the calculated result is the same as its effect on the experimental result.

This is necessary in order that the test for validation of calculation methods works: *Results of correct calculations with the benchmark model agree with experimental results.*

IRPhEP Evaluation - Section 3

Benchmark Model Consistency Requirement

(cont'd)

- Dimensions and material compositions of the benchmark model are consistent with experimental data.
- Values of dimensions and material compositions obtained from experimental data are not rounded, to preclude introduction of additional uncertainty.

This consistency requirement is important. Without this requirement, the value of our work is less and might even be counter-productive.

IRPhEP Evaluation -
Section 3.X.1 - Model Simplifications

- After a brief overview of the model, simplifications of the model compared to the experiment are described and justified.
- Additional uncertainty and corrections to the value of the parameter of interest due to model simplifications are derived.

IRPhEP Evaluation -
Sections 3.X.2 - 3.X.5
Benchmark Model Description

It is clear, complete, concise, and obviously consistent with the experiment.

3.X.2 - All model dimensions are shown in figures and explained in text.

3.X.3 - Material atom densities are given.

3.X.4 - Temperature of model is compared to experiment.

3.X.5 - Value and uncertainty of the *benchmark-model parameter of interest* are given.

The definition of the parameter of interest must be clear.

IRPhEP Evaluation - Section 4 Calculation Results

- The expected value of the *benchmark-model parameter of interest* (Section 3.X.5) is compared with a value calculated with the benchmark model (Section 3.X.2 - 3.X.5).
- The calculation method is described.
- Recommendations for calculation methodology may be given.

(Note: *These are only example calculations. They are not benchmarks.*)

Conclusion - The IRPhEP Handbook

- It provides the best available description of the experiments and measurement methods.
- It clearly explains what is known, so that users can judge the usefulness and reliability of the experiment and its model.
- The benchmark model is clearly and accurately derived from experimental data and is easy to use.
- Example calculation results and methodology are given.

Annex 6

Status of evaluations on VHTRC and TCA experiments

S. Okajima, JAEA

VHTRC-GCR-EXP-001

Overview of experiment

Two problems (VH1-HP and VHI-HC) are given on the base of heating experiments at the VHTRC (Very High Temperature Reactor Critical) Assembly which is a pin-in-block type core critical assembly loaded mainly with 4 % enriched uranium coated particle fuel.

(1) VH1-HP: The temperature coefficient of reactivity was derived from the subcritical reactivity measurements at five temperature steps between a room temperature where the assembly is nearly at critical state and 200°C.
(2) VH1-HC: The effective multiplication factor of nearly critical loading cores at the room temperature and 200°C.

Section 1 Almost finished
Section 2 Under preparation
Section 3 Under implementation (Calculation with JENDL-3.3)
Section 4 Under implementation (Calculation with JENDL-3.3)

TCA-FUND-EXP-001

Overview of experiment

Experimental studies on the temperature coefficients of reactivity in light-water moderated and reflected UO_2 cores with soluble poisons were carried out using the Tank-type Critical Assembly (TCA) in Japan Atomic Energy Research Institute (JAERI).

Temperature coefficients of the cores with soluble poisons were measured by changing the temperature of the moderator and reflector from the room temperature to about 60•‹C. The boron (H3B03) and gadolinium (Gd(N03)3) were used as soluble neutron poisons, which were selected to enlarge the capacity of the fuel dissolvers under the condition that the nuclear safety is assured. The operating conditions of the dissolvers were widely varied with temperature, and with volume ratio of solid fuel rod to fuel solution.

Section 1 Almost finished
Section 2 Under evaluation
Section 3 Under compilation (Calculation with JENDL-3.3 was finished)
Section 4 Under compilation (Calculation with JENDL-3.3)

Annex 7

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Potential Reactor Physics Experiments Performed at the IPEN/MB-01 Reactor Facility for the IRPhE Project.

By

Adimir dos Santos

IPEN-CNEN/SP
São Paulo - Brasil

1

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- **Experiments already Performed at the IPEN/MB-01 research reactor physics that can be of interest to the IRPhE project.**

a) **Effective kinetic parameters (β_{eff},β_{eff}/Λ, Λ, Relative Abundances and Decay Constants)**
b) **Power and fission density distribution**
c) **Spectral Indices ($^{28}\rho$, $^{25}\delta$, and $^{28}\delta$)**
d) **Buckling and extrapolation length**
e) **Reactivity measurements, reactivity coefficient**
f) **Reaction-rate distributions,**
g) **Others**

2

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A Few Results

a) Effective kinetic parameters (βeff,βeff/Λ, Λ, Relative Abundances and Decay Constants).

parameter	Rossi-α (reflector measurements)	Feynman-α (reflector measurements)	Frequency Analysis[a] NSE 2006	Frequency Analysis[b] ANE 2006
β_{eff}/Λ	$-234.42 s^{-1}$	$-235.25 s^{-1}$	$-234.61(3.26) s^{-1}$	$231.00(0.94) s^{-1}$
β_{eff}	$7.54(0.11)\times10^{-3}$	$7.50(0.05)\times10^{-3}$	$7.47(0.11)\times10^{-3}$	$7.42(0.07)\times10^{-3}$
Λ	32.03(1.33) μs	32.02(0.58) μs	32μs	31.99(0.33)μs

[a] With delayed neutron
[b] Without delayed neutron

3

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Theory/Experiment Comparison

		ENDF/B-VI.8[(a)]	JEFF-3.1	JENDL 3.3
β_{eff} (pcm)	TORT	792.38	774.38	756.16
	MCNP-4C3	781.6 ± 4.1	771.7 ± 4.1	755.6 ± 4.0
^{235}U Thermal yield		1.670×10^{-2}	1.620×10^{-2}	1.585×10^{-2}

		ENDF/B-VI.8[(a)]	JEFF-3.1	JENDL 3.3
Rossi-α C/E	TORT	1.0509	1.0270	1.0028
	MCNP-4C3	1.0366	1.0234	1.0021
Feynman-α C/E	TORT	1.0565	1.0325	1.0082
	MCNP-4C3	1.0421	1.0289	1.0074

4

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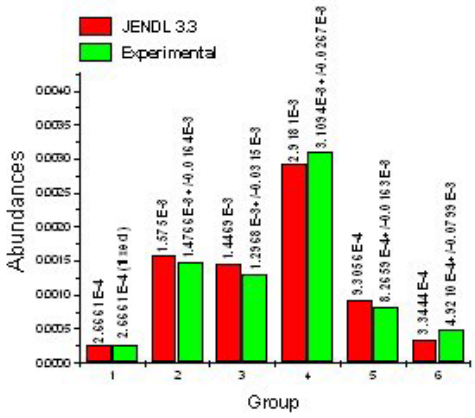
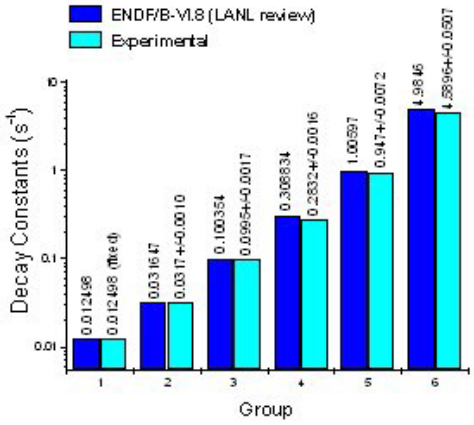
Numerical Results for Libraries with Best Performance





For the abundances, the JENDL3.3 library presents the best performance
For the decay constants, the LANL review version of ENDF/B-VI presents the best performance.

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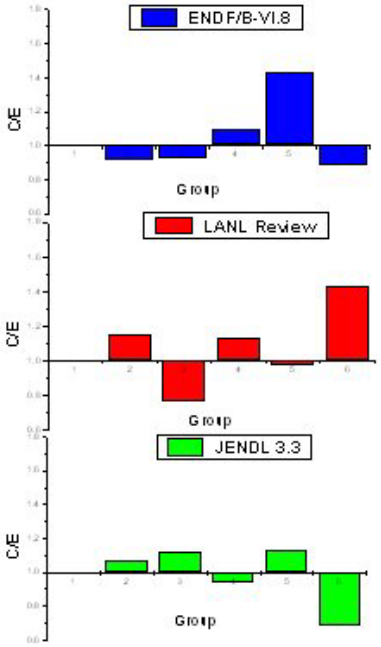
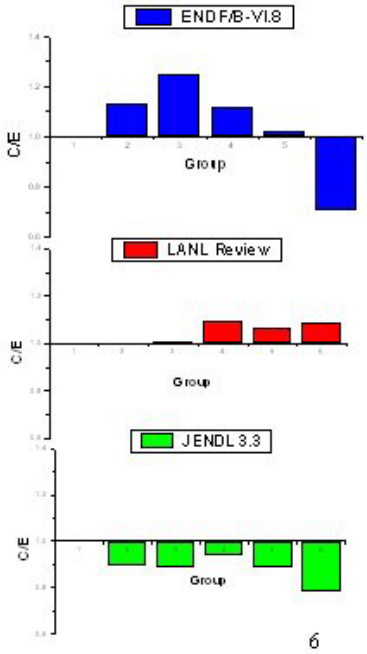
RESULTS

C/E Ratios





6

Abundances **Decay Constants**

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C/E Ratios for Reactivity

TABLE 2. Comparison theory/experiment for reactivity calculations

Period (s)	ENDF/B-VI.8	LANL review	JENDL3.3
1	0.976	0.973	1.034
10	0.890	0.959	1.081
100	0.838	0.983	1.124
200	0.834	0.985	1.129
-200	0.827	0.991	1.133
-100	0.844	0.985	1.100
-90	0.860	0.979	1.072
-85	0.875	0.973	1.044

Revised version at LANL of ENDF/B-VI.8 library presents the best performance.

7

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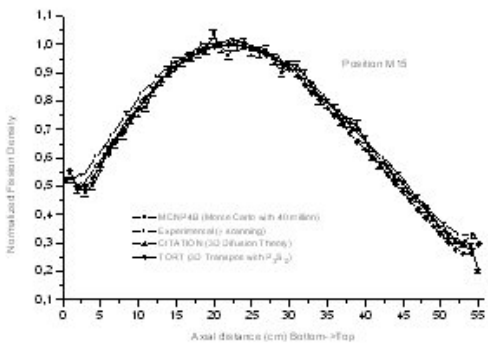
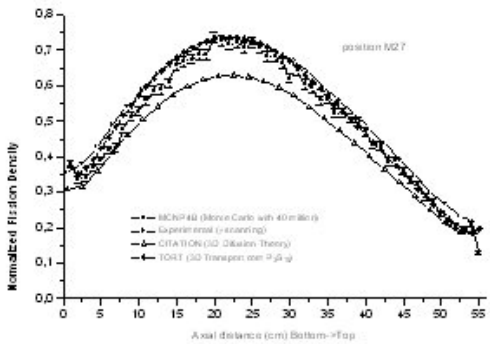
Fission Density Distribution





8

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Spectral Indices of the IPEN/MB-01 Reactor

Spectral Index	Fuel Rod Gamma Spectrometry	C/E ENDF/B-V	C/E ENDF/B-VI5	Foil Activation	C/E ENDF/B-V	C/E ENDF/B-VI5
$^{28}\rho$	2.3576 (0.39 %)	1.039 ± 0.008	1.023 ± 0.009	2.3575 (1.05 %)	1.039 ± 0.013	1.023 ± 0.013
$^{25}\delta$	0.1215 (0.38 %)	1.064 ± 0.007	1.035 ± 0.008	0.1241 (1.63 %)	1.042 ± 0.018	1.013 ± 0.018
$^{28}\delta$	-	-	-	0.0394 (1.92 %)	1.051 ± 0.021	1.050 ± 0.021
C^*	0.3206 (0.88 %)	1.030 ± 0.010	1.024 ± 0.012	-	-	-
C8/F	0.3124 (0.56 %)	1.015 ± 0.008	1.009 ± 0.011	-	-	-
$(C8/F)_{\varphi}$	1.6915 (0.93 %)	--	0.9752 ± 0.014	-	-	-

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Proposal for further evaluations:

2007: Effective kinetic parameters (βeff,βeff/Λ, Λ)
2008: Effective kinetic parameters (Relative Abundances, Decay Constants and Reactivities)
2009: Power and fission density distributions, and Buckling and extrapolation length
2010: Spectral Indices ($^{28}\rho$, $^{25}\delta$, and $^{28}\delta$),

etc., etc. ....

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Annex 8

Evaluation plan of JOYO MK-I depletion data

Taira Hazama, JAEA RPE gr.

1. Data
   - Burn-up reactivity measured in 5OMWth power ascension test, 50MWth 1st and 2nd cycles, and 75MWth 1st-4th cycles
     (Measured in 1978-1981. Several assemblies were replaced between cycles).

2. Measured parameters
   - Control rod positions, Power profile, temperature (at inlet and outlet of the core)
   - Typical data (reactivity loss of 0.4%Δk/k, constant power profile for 40days, 370°C inlet, 435°C outlet)

3. Evaluation
   - Power calibration
     - Determined from Na temperature, Flow rate, material constant
     - Uncertainties have been evaluated in detail (to be confirmed)

   - Reactivity evaluation (Control rod worth)
     - To be re-evaluated with the methodology employed in the previous JOYO data in IRPhE.
     - Influence of spatial distribution of temperature should be checked.

4. Benchmark data
   - Very complicated if everything into considered.
   - Approximation essential in composition, temperature, burn-up history

5. Working plan
   - Start evaluation in the next fiscal year (2007.4-)
   - Draft may be presented on 2007.10 (optimistic case)

Appendix A

SUMMARY OF EVALUATIONS DISCUSSED AT THE
IRPhEP TECHNICAL REVIEW GROUP MEETING
23 – 25 October 2006

Note: Appendix A is available to Evaluators and Reviewers in the IRPhE Project separately.