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NUCLEAR ENERGY AGENCY
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OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of LWRs (OECD LWR UAM Benchmark)

Expert Group on Uncertainty Analysis
Third Workshop (UAM-3)

University Park / State College, PA, USA
April 29 - May 1, 2009

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NUCLEAR SCIENCE COMMITTEE

and

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

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April 29 - May 1, 2009

Hosted by
The Pennsylvania State University (PSU)
USA

SUMMARY RECORD

OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of LWRs (OECD LWR UAM Benchmark)

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SUMMARY RECORD

Sponsorship

The third workshop for the OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of LWRs **(**UAM-3**)** was held from April 29 to May 1, 2009 in University Park / State College, Pennsylvania, USA, and was a follow up to the first and second workshops. The first workshop for the OECD UAM LWR benchmark (UAM-1) was held on 10 and 11 May 2007 at the OECD/NEA Headquarters, Issy les Moulineaux, France. The second workshop for the OECD UAM LWR benchmark (UAM-2) was held from 2 to 4 April 2008 in Garching, Germany.

In recent years there has been an increasing demand from nuclear research, industry, safety and regulation for best estimate predictions to be provided with their confidence bounds. Consequently an "in-depth" discussion on “Uncertainty Analysis in Modelling” was organized at the 2005 OECD/NEA Nuclear Science Committee (NSC) meetings, which led to a proposal for launching an Expert Group on "Uncertainty Analysis in Modelling" and the endorsement to hold a workshop with the aim of defining future actions and a program of work.

As a result the OECD/NEA Workshop on Uncertainty Analysis in Modelling took place in Pisa, Italy, on April 28-29, 2006 (UAM-2006). The major outcome of the workshop was to prepare a benchmark work program with steps (exercises) that would be needed to define the uncertainty and modelling task. The other proposals made during the meeting would be incorporated under the different steps (exercises) within the overall benchmark framework for the development of uncertainty analysis methodologies for multi-physics (coupled) and multi-scale simulations.

Following the results from the UAM-2006 Workshop the OECD/NEA Nuclear Science Committee at its June 2006 meeting endorsed the creation of an Expert Group on Uncertainty Analysis methods in Modelling. This Expert Group will report to the Working Party on Scientific issues of Reactor Systems (WPRS). Since it addresses multi-scale / multi-physics aspects of uncertainty analysis, it will work in close co-ordination with the benchmark groups on coupled neutronics-thermal-hydraulics simulations and on coupled core-plant problems. The Expert Group will also coordinate its activities with the Group on Analysis and Management of Accidents (GAMA) of the Committee on Safety of Nuclear Installations (CSNI). The Expert Group has the following mandate:

1. To elaborate a state-of-the-art report on current status and needs of sensitivity and uncertainty analysis (SA/UA) in modelling, with emphasis on multi-physics (coupled) and multi-scale simulations.
2. To identify the opportunities for international co-operation in the uncertainty analysis area that would benefit from coordination by the NEA/NSC.
3. To create a roadmap along with schedule and organization for the development and validation of methods and codes required for uncertainty analysis including the benchmarks adequate to meet those goals.

The NEA/NSC has endorsed that this activity be undertaken with PSU as the main coordinator and host with the assistance of the Scientific Board. The 40 participants in the UAM workshop in Pisa (from 26 organizations in 16 countries representing industry, regulatory agencies, national laboratories and research institutions) expressed interest in participating and contributing to this UAM Expert Group and proposed an uncertainty analysis benchmark activity.

To summarize, in addition to LWR best-estimate calculations for design and safety analysis, the different aspects of uncertainty analysis in modelling (UAM) are to be further developed and validated on scientific grounds in support of its performance. There is a need for efficient and powerful analysis methods suitable for such complex coupled multi-physics and multi-scale simulations. The proposed benchmark sequence will address this need by integrating the expertise in reactor physics, thermal-hydraulics and reactor system modelling as well as uncertainty and sensitivity analysis, and will contribute to the development and assessment of advanced/optimized uncertainty methods for use in best-estimate reactor simulations. Such an effort can be undertaken within the framework of a program of international co-operation that would benefit from the coordination of the NEA/NSC and all participants by interfacing with the CSNI activities.

The UAM-3 workshop was held in conjunction with other meetings, in order to facilitate co-ordination and sharing of work. Two other meetings were held during the same week in order to combine efforts in common areas such as CFD modelling and uncertainty analysis and to make participation more efficient. The meetings concerned were the First OECD Kalinin-3 VVER-1000 Benchmark Workshop (Kalinin-2009) and the OECD/NRC BFBT-6 benchmark workshop. The OECD/NRC BFBT-6 and the First OECD Kalinin-3 workshops were held in parallel on April 27-28, 2009 followed by the OECD UAM-3 benchmark workshop (April 29 - May 1, 2009) which was hosted by PSU, USA. The 3 workshops took place in University Park / State College, Pennsylvania (located in the Happy Valley) – home of PSU.

Background and Purpose of the Benchmark Workshop

The objective of the work is to define, conduct, and summarize an OECD benchmark for uncertainty analysis in best-estimate coupled code calculations for design, operation, and safety analysis of LWRs. The title of this benchmark is: **"OECD UAM LWR Benchmark"**. Reference systems and scenarios for coupled code analysis are defined to study the uncertainty effects for all stages of the system calculations. Measured data from plant operation are available for the chosen scenarios.

The proposed technical approach is to establish a benchmark for uncertainty analysis in best-estimate modelling and coupled multi-physics and multi-scale LWR analysis, using as basis a series of well defined problems with complete sets of input specifications and reference experimental data. The objective is to determine the uncertainty in LWR system calculations at all stages of a coupled reactor physics/thermal hydraulics calculation. The full chain of uncertainty propagation from basic data, engineering uncertainties, across different scales (multi-scale), and physics phenomena (multi-physics) are tested on a number of benchmark exercises for which experimental data are available and for which the power plant details have been released. The principal idea is: a) to subdivide the complex system/scenario into several steps or Exercises, each of which can contribute to the total uncertainty of the final coupled system calculation, b) to identify input, output, and assumptions for each step, c) to calculate the resulting uncertainty in each step; d) to propagate the uncertainties in an integral systems simulation for which high quality plant experimental data exists for the total assessment of the overall computer code uncertainty. The main scope covers uncertainty (and sensitivity) analysis (SA/UA) in best estimate modelling for design and operation of LWRs, including methods that are used for safety evaluations. As part of this effort, the development and assessment of different methods or techniques to account for the uncertainties in the calculations will be investigated and reported to the participants.

The general frame of the OECD LWR UAM benchmark consists of three phases with three exercises for each phase:

Phase I (Neutronics Phase)

- Exercise 1 (I-1): "Cell Physics" focused on the derivation of the multi-group microscopic cross-section libraries
- Exercise 2 (I-2): "Lattice Physics" focused on the derivation of the few-group macroscopic cross-section libraries
- Exercise 3 (I-3): "Core Physics" focused on the core steady state stand-alone neutronics calculations

Phase II (Core Phase)

- Exercise II-1: Fuel thermal properties relevant for transient performance
- Exercise II-2: Neutron kinetics stand-alone performance (kinetics data, space-time dependence treatment, etc.)
- Exercise II-3: Thermal-hydraulic fuel bundle performance

Phase III (System Phase)

- Exercise III-1: Coupled neutronics/thermal-hydraulics core performance (coupled steady state, coupled depletion, and coupled core transient with boundary conditions)
- Exercise III-2: Thermal-hydraulics system performance
- Exercise III-3: Coupled neutronics kinetics thermal-hydraulic core/thermal-hydraulic system performance

The expected impact and benefits of the OECD LWR UAM benchmark activity for LWR safety and licensing are summarized in "Technology Relevance of the Uncertainty Analysis in Modelling. Project for Nuclear Reactor Safety", NEA/NSC/DOC (2007)15:

a) Systematic identification of uncertainty sources;
b) Systematic consideration of uncertainty and sensitivity methods in all steps. This approach will generate a new level of accuracy and will improve transparency of complex dependencies;
c) All results will be represented by reference results and variances and suitable tolerance limits;
d) The dominant parameters will be identified for all physical processes;
e) Support of the quantification of safety margins;
f) The experiences of validation will be explicitly and quantitatively documented;
g) Recommendations and guidelines for the application of the new methodologies will be established.

This benchmark project is challenging and responds to needs of estimating confidence bounds for results from simulations and analysis in real applications. Separate Specifications will be prepared for each Phase in order to allow participation in the full Phase or only in a subset of the Exercises. Boundary conditions

and necessary input information are provided by the benchmark team. The intention is to follow the calculation scheme for coupled calculations for LWR design and safety analysis established in the nuclear power generation industry and regulation. The specification document that covers Phase I (which includes the first 3 Exercises) was distributed to the participants - "Benchmark for Uncertainty Analysis in Modelling (UAM) for Design, Operation and Safety Analysis of LWRs. Volume I – Specification and Supporting Data for the Neutronics Cases (Phase I) Version 1.0", NEA/NSC/DOC(2007)23. The Version 2.0 (final) of the Volume I of OECD LWR UAM Benchmark Specification (Phase I) based on the participants' feedback obtained during the UAM-2 and UAM-3 workshops will be distributed to the participants in June 2009. Version 1.0 (draft) of Volume II of OECD LWR UAM Benchmark Specification (Phase II) was discussed at the UAM-3 workshop and will be distributed to the participants in August 2009.

Scope and Technical Content of the Benchmark Workshop

The technical topics addressed at the workshop included:

- Review of the benchmark activities after the UAM-2 Workshop
- Discussion of the updated final specification for Phase I
- Discussion of submitted results of Phase I
- Participants'' presentation on their modelling and results for Phase I
- Discussion of draft Specification for Phase II
- Discussion of priorities for PhaseIII
- Presentations on participants' experience and expertise in uncertainty and sensitivity analysis of LWRs
- Defining a work plan and schedule outlining actions to progress on the three phases of the benchmark activities

The meeting was organized around the discussion in depth of the Version 2.0 (final version) of the Volume I (Specification of Phase I of the UAM LWR benchmark), preliminary results of Phase I, Version 1.0 (draft version) of Volume II (Specification of Phase II), output parameters and format as well as priorities for Phase III, and the proposed work plan and time schedule for the UAM LWR benchmark activities. The participants presented their experience and expertise in uncertainty and sensitivity analysis of LWRs.

Organization and Programme Committee of the Benchmark Workshop

An Organization and Programme Committee has made the necessary arrangements for the first Benchmark Workshop, organized the Sessions, and prepared the final program. The general chair was K. Ivanov (PSU), who hosted the meeting. The other members were J. Aragonés (UPM), representing the NSC, F. D'Auria (UP), representing CSNI, E. Royer (CEA-Saclay), D. Cacuci (CEA-Scalay), M. Zimmermann (PSI), T. Downar (UM), S. Kliem (FZR), H. Utsuno (JNES), A. Hotta (TEPSYS), Y. Hassan (TAMU), M. Williams (ORNL), A. Pautz (GRS), M. Avramova (PSU) representing the UAM scientific board, and E. Sartori from the OECD/NEA Secretariat.

Opening Session – Introduction and opening remarks

Prof. K. Thole, Head of Mechanical and Nuclear Engineering Department, welcomed the participants on behalf of PSU, hosting the workshop. Prof. J. Aragonés, representing the NSC of NEA/OECD, underlined the importance of consistent propagation of uncertainties through multi-physics and multi-scale

calculations using a unified benchmark framework. The OECD LWR UAM benchmark framework is expected to help formulating recommendations and guidelines on how to utilize advanced and optimized sensitivity analysis and uncertainty analysis (SA/UA) methods in "best estimate" reactor simulations in licensing practices.

The agenda was approved with minor amendments (see Annex I).

The workshop was attended by 44 participants from 28 organizations in 13 countries. The list of participants is given in Annex II. The group of participants in this benchmark includes experts from different fields namely in thermal-hydraulics, neutronics and uncertainty analysis. Several expert groups had been formed previously each addressing specific benchmark problems and now they are combining in this long term effort aimed at establishing best-estimate simulation methods with systematic uncertainty analysis across different phenomena (multi-physics) and different scales (multi-scales).

K. Ivanov on behalf of the benchmark team made a presentation giving an overview and status of the UAM benchmark activities.

E. Sartori discussed in his presentation the report from the last WPRS meeting, which took place on 26-27 February 2009. This UAM Expert Group reports to the Working Party on Scientific issues of Reactor Systems (WPRS).

Technical Sessions on Phase I

Sessions I through V were devoted to discussion of the Version 2.0 of the Volume I of Specification (Specification and Supporting Data for the Phase I) as well as of the preliminary results obtained by participants for Exercise I-1 and Exercise I-2. First, the improved and extended SCALE covariance library (available with SCALE-6) and updated versions of tools provided by the NEA/OECD for handling and transforming the cross-section covariance in a consistent way (ANGELO-LAMBDA) were presented and discussed. The later utility programs for interpolation and mathematical verification of the matrices were extended to handle the 44-group covariances available in SCALE-6. NEA/OECD will provide ANGELO-LAMBDA together with the corresponding library ZZ-SCALE6/COVA-44G to the participants by the end of May 2009. The quantification and the treatment of self-shielding effect within the framework of Exercise I-1 were discussed on the example of the explicit and implicit approaches. The benchmark team will acknowledge the effect and try to quantify it as an example. The self-shielding effect on covariance information and uncertainties has been singled out as one that needs special attention for developments required in Phase I..

In Session II the updated definition, test problems and requested output of Exercise I-1 were discussed. The updates have been made following the participants' comments and suggestions made at the UAM-2 workshop. After a discussion final agreement on the above topics was achieved, and this will be reflected in the Version 2.0 (final version) of Volume I of Specification:

- Perform one-group effective uncertainty calculation for comparison purpose only;
- Include HFP cases in the requested output as well as HZP;
- Develop the following templates for submitting results for Exercise I-1:

  Part I
  - One-group effective uncertainties from the top five nuclide contributors to the uncertainty in k_{inf} for each pin-cell test model;
  - Include variance from each matrix read;

- Include un-weighted (α=1) one-group effective uncertainties from each matrix read.

Part II

- For each model: k_{inf} and associated uncertainty;
- For each model: Fission reaction rate and associated uncertainty for U-235 and U-238;
- For each model: Absorption reaction rate and associated uncertainty for U-235 and U-238.

In Session III the comparative analysis of submitted results for Exercise I-1 was presented followed by reference Monte Carlo results for the different pin-cell test problems at HZP and HFP conditions. The reference solutions with Monte-Carlo (MCNP5) simulations were performed with different nuclear data libraries in order to assess the effect of evaluated nuclear data on well defined problems. Further some participants showed their results for Exercise I-1 and discussed their methods and approaches.

In Session IV the updated definition, test problems and requested output for Exercise I-2 were presented followed by a discussion on obtaining reference solutions with MCNP5. For MCNP cases it was suggested to model both continuous energy and multi-group cases in order to show the differences in self shielding effects. Propagation of methodological, numerical and manufacturing uncertainties in Exercise I-2 will be addressed in Version 2.0 of Volume I of the Specification by the benchmark team but the participants will be advised to focus mostly on cross-section uncertainty propagation. It was suggested that in addition to evaluating few-group homogenized cross-section uncertainties the uncertainty of assembly (lattice) based kinetics parameters such as delayed neutron fractions to be estimated also. Since there are no available covariance matrices for delayed neutron data in evaluated nuclear data files the information form relevant publications based on experiments for the most important actinides will be used. The benchmark team will quantify the modelling uncertainties in calculating effective delayed neutron fractions and provide them to the participants. In regard to the selected test problems for Exercise I-2 it was suggested to add a BWR test problem (using the PB-2 assembly test case) with 40% void in order to investigate the propagation of uncertainties in case of HFP spectrum conditions with high void (taking into account the uncertainties in void predictions). In other words HFP case will be modelled to estimate the uncertainty due to void effects. For the experimental based test cases (Kritz experiments) it was recommended that the latest edition of the International Reactor Physics Experiments Database Project (IRPhE), "International Handbook of Evaluated Reactor Physics Benchmark Experiments" (from March 2009) be used.

In Session V**,** the updated definition, test problems and requested output for Exercise I-3 were presented followed by the participants' presentations on their uncertainty analysis and propagation methods, as well as calculation models and results relevant to Exercises I-2 and I-3. Exercise I-3 (Core Physics) computes uncertainties at core level. The suggested output parameters to be compared with their associated uncertainties are k_{eff}, assembly power (radial) distribution, axial core averaged power distribution and axial offset, relative pin power distribution and assembly reaction rates for selected fuel assemblies and axial layers (nodes), control rod worth, and core average (point) kinetic parameters. Special attention should be paid to relative power distributions, which are correlated to the normalized values. Concerning pin power, the pin power reconstruction is the main technique currently used. The benchmark team will provide uncertainties associated with pin-power reconstruction techniques. It was recommended that the same uniform format for the few-group cross-section variance and covariance matrices to be specified by the benchmark team and used by the participants in Exercise I-3. The benchmark team will specify the format of the 44-group and 2-group variance and covariance cross-section matrices to be used in Phase I.

Similar to Exercise I-2 in Exercise I-3 the propagation of modelling, numerical and geometry variation uncertainties will be addressed in Version 2.0 of Volume I of the Specification by the benchmark team but the participants will be advised to focus mostly on cross-section uncertainty propagation. For participants who want to take part directly in Exercise I-3 the benchmark team will provide reference 2-group cross-section data and associated variance and covariance matrices for the three representative types of LWRs – TMI-1, PB-2 and VVER-1000. The benchmark team will provide also the uncertainties in kinetics

parameters using the available measured and experimental data. Finally, it was suggested to include test cases for a fast reactor core based on the SNEAK data as a part of Exercise I-3, and several participants expressed interest in analyzing such cases.

Technical Sessions on Phase II

Sessions VI, VII and VIII were devoted to discussing draft Specifications (Volume II Version 1.0), support data, output parameters and format for Phase II. The GRNSPG/UNIPI proposal for Phase II of the UAM benchmark was followed by presentations of the benchmark team and discussions in detail of each exercise within the framework of Phase II.

The Exercise II-1(Fuel thermal properties relevant for transient performance) will focus on identifying and propagating input uncertainties in simple standard fuel rod models (average rod representing a fuel assembly, group of assemblies or the whole core) used in the current core simulation tools for steady-state and transient analysis. More sophisticated fuel performance codes such as FRAPCON and FRAPTRAN will be utilized for obtaining reference solutions. The output uncertainty parameter of interest in this Exercise is the nodal fuel (Doppler) temperature. The definition for calculation of Doppler temperature will be provided to the participants by the benchmark team. Input uncertainties include the fuel pellet nodalization, gas gap composition, as well as cladding, fuel and gap conductivities. For some conductivities the uncertainties of utilized correlations will be taken into account. The fuel conductivity has burnup dependence, which can be treated either in a simple way or can be left for Phase III. For steady state simulations the input uncertainties (such as uncertainties of thermal conductivities) will be propagated to the uncertainty of Doppler temperature prediction. The benchmark team will use the FRAPTRAN code to study the problem definition for transient simulations. For Exercise II-1 the available experimental data can be identified from the CRISSUE-S database. The Halden data will be checked out for appropriate transient fuel thermal property data.

In Exercise II-2 (Neutron kinetics stand-alone performance) the participants will propagate few-group (two-group) nodal cross-section variance and covariance matrices for both unrodded and rodded cross-sections plus uncertainties of nodal kinetics parameters (inverse neutron group velocities, delayed neutron fractions and decay constants) through a well-defined transient to obtain uncertainties in prediction of output parameters such as total power and reactivity time evolution as well as time-dependent spatial power distributions. The simulated transient is a control rod movement for three numerical mini-core test problems representatives of TMI-1, PB-2 and VVER-1000. In addition, the publicly available kinetics experiments relevant to the three LWR types will be searched by the benchmark team with the help of the participants – for example the SPERT experiment and the Rez data for VVER.

For Exercise II-3 (Fuel bundle thermal-hydraulics), measured data is available for the BWR bundle type (from the OECD/NRC BFBT benchmark), and for the PWR bundle (from the OECD PSBT benchmark) but there is a need for a VVER bundle data. The possibility for obtaining such data will be checked out with Obninsk and Gidropress. Uncertainty analysis exercises have been defined within the framework of the BFBT benchmark for BWR bundle including input and output uncertainties. Similar exercises will be defined for PWR and VVER bundles. While Exercise II-1 determines the uncertainty in fuel temperature prediction (which is related to the Doppler feedback prediction) Exercise II-3 determines uncertainty in predicting moderator parameters (which is related to the moderator feedback reactivity).

Technical Sessions on Phase III

In Sessions IX and X, the participants presented their experience and expertise in uncertainty analysis of coupled neutronics/ thermal-hydraulics calculations for current generation LWRs as well as for next generation PBMRs. The benchmark team presented a vision for priorities, output parameters and format

for Phase III of the UAM benchmark activities. In the follow-up discussion the following suggestions and recommendations were accepted by the participants in the workshop. Thoughts should be given to the interactions between the prediction uncertainties and modelled control system actions. It is very important to select appropriate transients with available measured data of good quality to be analyzed in Phase III. The final objective is to compare the code predictions + uncertainties with measured data + uncertainties. PB-2 Turbine Trip data and Kalinin-3 VVER coolant transient data are appropriate. For appropriate TMI-1 transient data the CRISSUE database can be utilized.

The Specifications for the three Phases are being prepared in such a way that allows participation in the full Phase or only in a subset of the Exercises or in a separate Exercise. Boundary conditions and necessary input information will be provided by the benchmark team. Each organization interested in the UAM benchmark has to identify its own objectives and priorities.

Conclusions, Actions and Schedule

In summary, at the UAM-3 workshop the benchmark team presented in total 20 presentations supplemented by 14 presentations from participants. The action items and schedule of benchmark activities were discussed. They are provided in the following list. The OECD/NEA Secretariat thanked the Reactor Dynamics and Fuel Management Research Group of PSU for hosting the workshop and for the outstanding organization behind it. Particular appreciation was expressed for the perfect and convincing co-ordination work of distinguished Professor Kostadin Ivanov.

List of Agreed Actions

1. End of May 2009 – Summary of the UAM-3 workshop (NEA/NSC document)
2. End of May 2009 – CD-Rom with all presentations of the UAM-3 workshop
3. End of May 2009 – Updated version of ANGELO/LAMBDA + SCALE-6 44-group variance / covariance data library
4. End of June 2009 – Version 2.0 of the Volume I of OECD LWR UAM Benchmark Specification (Phase I)
5. End of July 2009 – Templates for submission results for the 3 exercises of Phase I
6. End of August 2009 – Version 1.0 (draft) of the Volume II of OECD LWR UAM Benchmark Specification (Phase II)
7. End of January 2010 – Deadline for submission results for Exercises I-1 and I-2
8. End of February 2010 - Deadline for submission results for Exercises I-3 and II-1
9. End of March 2010 - Deadline for submission results for Exercises II-2 and II-3
10. April 14-16, 2010 – UAM-4 workshop

There will be a special session on LWR UAM in multi-physics multi-scale simulations at the PHYSOR-2010 Conference in Pittsburgh, PA in May 2010. End of October 2009 is the deadline for submitting draft full papers for the Special UAM session at PHYSOR-2010 conference. Participants in the OECD LWR UAM benchmark have preference for invitation to contribute to this session – please contact Kostadin Ivanov (kni1@psu.edu) by the end of August 2009 if you want to participate in this session.

The UAM-4 workshop will be held in conjunction with other meetings, in order to facilitate co-ordination and sharing of work. The three other meetings will be held at the same place and during the same week in order to combine efforts in common areas such as thermal-hydraulic modelling and uncertainty analysis and to make the participation more efficient. The UAM-4 workshop will be held in conjunction with the AER Working Group D (VVER dynamics and safety) meeting, the OECD PSBT-1 benchmark workshop and the Second Kalinin-3 (K-2) benchmark workshop. The OECD PSBT-1 and K-2 workshops will be held in parallel on April 12-13, 2010. The OECD UAM-4 workshop and the AER Working Group D meeting will take place on April 14-16, 2010. There are two options for location of the four workshops in April 2010 – one is at the NEA/OECD, Paris, France (room reservations have been made) and the other is at University of Pisa, Pisa, Italy. It was suggested also that the four workshops could take place in USA in May 2010 before or after the PHYSOR-2010 conference. The NSC committee will decide on the location of the four workshops for 2010. KTH, Sweden is ready to host the four workshops in 2011.

The objectives of the next workshop (UAM-4) will be the following:

a) Discussion of submitted results for Phase I

b) Finalizing the Specification for Phase II

c) Discussion of submitted results for Phase II

d) Discussion of draft Specification for Phase III

Annex I

OECD/ Nuclear Energy Agency
Working Party on Scientific Issues of Reactor Systems (WPRS)

OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of LWRs - Third Workshop (UAM-3)

Hosted by
The Pennsylvania State University (PSU), USA
April 29-May 1, 2009

AGENDA [U301]

Day 1: April 29, 2009 – Regency B Room at the Atherton Hotel

Opening Session – Chair K. Ivanov

08:30 - 08:50 Introduction and opening remarks and list of participants [U302]
- K. Thole, Head of Mechanical and Nuclear Department, PSU [U303]
- J. Aragonés, Nuclear Science Committee of OECD/NEA [U304]

08:50 – 09:00 Overview and status of benchmark activities
- K. Ivanov [U305]

09:00 – 09:10 Oral Report from the last WPRS meeting, 26-27 February 2009
Structure of the Working Party on scientific issues in Reactor Systems (WPRS) - Work Areas / Subgroups
- E. Sartori [U306]

Technical Sessions on Phase I

Session I – Chair T. Downar

09:10 – 09:40 Status of Sensitivity and Uncertainty Analysis Tools Available / Developed at the NEA Data Bank
- Kodeli, E. Sartori [U307]

09:40 – 10:10 Updated Covariance Library for SCALE6
- M. Williams, G. Arbanas, M. Dunn, D. Wiarda [U308]

10:10- 10:35 Activities in CSN's Core Engineering Branch in relation to uncertainty analysis
- R. Mendizábal [U309]

10:35 – 10:45 Coffee Break

Session II – Chair A. Pautz

10:45 – 11:10 Updated definition for Exercise 1 of Phase I (I-1) - Cell Physics
- K. Ivanov, M. Avramova [U310]

11:10 – 11:30 Updated test problems for Exercise I-1
- K. Ivanov, M. Avramova [U311]

11:30 – 12:00 Updated requested output for Exercise I-1
- S. Kamerow [U312]

12:00 – 13:00 Lunch – Regency A Room at the Atherton Hotel

Session III – Chair M. Williams

13:30 – 14:00 Review of submitted results on Exercises I-1
- S. Kamerow [U313]

14:00 – 14:25 Monte Carlo solutions of selected test problems for Exercise I-1
- F. Puente Espel, S. Ghrayeb, K. Ivanov [U314]

14:25 – 14:50 Application of global sensitivity analysis approach to Exercise I-1
- F. Puente Espel, S. Ghrayeb, S. Tarantola, K. Ivanov [U315]

14:50 – 15:15 Results on Exercise I-1 by an ERRORJ/SUSD3D with JENDL-3.3 covariance data
- T. Sakai [U316]

15:15- 15:40 Calculations at VTT
- M. Pusa [U317]

15:40 – 15:55 Coffee Break

Session IV – Chair G. Verdu

15:55 – 16:25 Updated definition for Exercise 2 of Phase I (I-2) - Lattice Physics
- K. Ivanov, M. Avramova [U318]

16:25 – 16:55 Updated test problems and requested output for Exercise I-2
- K. Ivanov, M. Avramova [U319]

16:55 – 17:20 Monte Carlo solutions of selected test problems for Exercise I-2
- S. Ghrayeb, F. Puente Espel, K. Ivanov [U320]

19:00 – Banquet – Regency A Room at the Atherton Hotel

Day 2: April 30, 2009 – Regency B Room at the Atherton Hotel

Session V – Chair H. Gougar

08:30 – 09:00 Updated definition for Exercise 3 of Phase I (I-3) - Core Physics
- K. Ivanov, M. Avramova [U321]

09:00 – 09:30 Updated test problems and requested output for Exercise I-3
- K. Ivanov, M. Avramova [U322]

09:30 – 09:55 Investigations on the influence of nuclear covariance data on the uncertainties in LWR core calculations
- B. Krzykacz, L. Gallier, A. Pautz, W. Zwermann [U323]

09:55 – 10:20 GRNSPG/UNIPI activities for UAM Phase I Benchmark
- C. Parisi, M. Ball, F. D'Auria [U324]

10:20-10:45 Update on a proposed benchmark for Stochastic and Deterministic Analyses of Nuclear Data Sensitivities and Uncertainties - SNEAK-7A & 7B case
- I. Kodeli, A. Bidaud, V. Mastrangelo, presented by E. Sartori[U325]

10:45 – 11:00 Coffee Break

Technical Sessions on Phase II

Session VI – Chair M. Zimmermann

11:00 – 11:30 Uncertainty Analysis Framework for Multi-scale Analysis Codes
- Hany Abdel-Khalik [U326]

11:30 – 12:15 GRNSPG/UNIPI proposal for Phase II of the UAM benchmark
- A. Del Nevo, C. Parisi, A. Petruzzi, F. D'Auria [U327]

12:15 – 13:00 – Lunch – Regency A Room at the Atherton Hotel

Session VII – Chair S. Kliem

13:30 – 14:00 Definition for Exercise 1 of Phase II (II-1) - Fuel thermal properties relevant for transient performance
- K. Ivanov, M. Avramova [U328]

14:00 – 14:30 Test problems and requested output for Exercise II-1
- K. Ivanov, M. Avramova [U329]

14:30 – 15:00 Definition for Exercise 2 of Phase II (II-2) - Neutron kinetics stand-alone performance
- K. Ivanov, M. Avramova [U330]

15:00 – 15:30 Test problems and requested output for Exercise II-2
- K. Ivanov, M. Avramova [U331]

15:30 – 15:45 Coffee Break

Session VIII – Chair C. Parisi

15:45 – 16:10 « BWR Full-size Fine-mesh Bundle Tests » (BFBT) a NUPEC Database for FLICA4 Validation in BWR Conditions and Uncertainty Analysis with URANIE platform
M. Martin, F. Gaudier, D. Caruge [U332]

16:10-16:35 Preliminary Analysis of the Sensitivity of the BWR Core Performance to the Uncertainty in the Void Fraction
- Y. Xu, T. Downar [U333]

16:35-17:00 Definition for Exercise 3 of Phase II (II-3) - Thermal-hydraulic fuel bundle performance
- M. Avramova, K. Ivanov [U334]

17:00–17:25 Test problems and requested output for Exercise II-3
- M. Avramova, K. Ivanov. [U335]

<u>Day 3: May 1, 2009 – Regency B Room at the Atherton Hotel</u>

Technical Sessions on Phase III

Session IX – Chair D. Caruge

09:00 – 09:30 Uncertainty analyses of coupled thermal hydraulic/neutron kinetic code calculations for transients at NPPs with VVER reactors.
- S. Kliem, S. Langenbuch, F.-P. Weiss [U336]

09:30 – 10:00 Uncertainty Quantification in Pebble Bed High Temperature Reactors
- H. Gougar, F. Reitsma, G. Strydom [U337]

10:00 – 10:15 Coffer break

Session X – Chair M. Avramova

10:15 – 11:00 Discussion on the priorities for Phase III
- K. Ivanov [U338]

11:00 – 11:30 Discussion on output parameters and format for Phase III
- K. Ivanov [U339]

11:30 – 11:50 Action items and schedule of benchmark activities - next workshop (UAM-3) and plans [U340], [U341]
- K. Ivanov, M. Avramova, E. Sartori

11:50 -12:00 Conclusions and closing remarks
- K. Ivanov

12:00 – 13:00 Lunch – Regency A Room at the Atherton Hotel

Annex II

UAM-3 Third Workshop on Uncertainty Analysis in Modelling

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** regrets not to have been able to attend*