

**NUCLEAR SCIENCE COMMITTEE  
and  
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS**

**OECD/DOE/CEA  
VVER-1000 Coolant Transient Benchmark  
Ad-hoc meeting (V1000CT 4.5)**

Vancouver, BC, Canada  
12 September, 2006

Hosted by  
PHYSOR-2006 Conference

**Summary of Meeting**

**OECD/DOE/CEA  
VVER-1000 Coolant Transient Benchmark  
Ad-hoc meeting (V1000CT 4.5)**

(Vancouver, Canada, 12 September 2006)

**Sponsorship**

This Ad-hoc meeting for the VVER-CT benchmark was held on 12 September 2006 in Vancouver, Canada, during the Physor-2006 International Conference. It is a follow-up to the following events: the fourth workshop hosted by the University of Pisa on 23-25 April 2006, the ad-hoc meeting held during the NURETH-11 conference, Avignon, France, on 4 October 2005, the third workshop, hosted by GRS, Garching, Germany, on 4-5 April 2005, the second workshop, hosted by INRNE and KNPP, Bulgaria Sofia, Bulgaria, on 5-6 April 2004, the first workshop hosted by the CEA-Saclay (Paris), France, on 12-13 May, 2003, and to the starter meeting hosted by the Forschungszentrum Rossendorf (FZR), Germany on 30 May, 2002. The V1000-CT Benchmark is sponsored by the US DOE, OECD, CEA, and the Nuclear Engineering Program (NEP) of the Pennsylvania State University (PSU). The NEP, PSU (USA), CEA-Saclay (France) and the Institute of Nuclear Research and Nuclear Energy (INRNE), Sofia (Bulgaria), perform these international benchmark activities in collaboration and with the assistance of the ANL (USA) and the Kozloduy nuclear power plant (NPP) – KNPP (Bulgaria).

**Scope and Technical Content of the Benchmark Meeting**

The technical topics presented at this meeting were as follows:

- Clarify the cross-sections for V1000CT2 Exercises 2 and 3
- Present and discuss the results of V1000CT2 Exercises 2
- Present and discuss the results of V1000CT2 Exercises 3
- Update the work plan and actions

The Agenda is provided as Annex I.

**Organization of the Benchmark Meeting**

The meeting was organized around the discussion of Exercises 2 and 3 of Phase 2. Presentations on related experience in VVER core and system modelling were encouraged.

**Participation in the Benchmark Meeting**

The meeting was held in connection with the Physor-2006 International Conference in order to facilitate attendance of benchmark participants who were presenting papers on this and similar topics at the conference. The list of participants is enclosed as Annex II.

## **Summary**

### **Discussion of cross-section library for MSLB simulation**

MSLB simulation is the objective of V1000CT2 Exercises 2 and 3, respectively using vessel boundary conditions and full plant model. During the previous meeting in Pisa, discrepancies were displayed on the axial power profile between the benchmark team and BIPR8 computations. Further analysis was carried out by the benchmark team, which resulted in several improvements in the core and reflector neutronic models. Finally, a second version of the cross-sections have been prepared by Penn State using Helios and were presented by B. Ivanov. The main differences with the first version are:

- i) the number of axial layers in the fuel region are increased from ten to thirty, which results in a total number of compositions of 843;
- ii) the range of thermal-hydraulic parameters is extended in order to avoid extrapolation in Hot Zero Power conditions and also during the MSLB transient.

There is still the possibility to derive Assembly Discontinuity Factors by participants if they wish.

The verification of the cross-section library is mainly based on the Kozloduy plant data available at 92% of nominal power, end of cycle 8 (270 EFPD). The results obtained by the benchmark team both with PARCS/TRACE and CRONOS2/FLICA4 agree well with the measured data (2D power map and axial power profile), and also with the independent BIPR8 calculations. The Doppler and moderator coefficients are also compared with BIPR8, and reasonable agreement is obtained.

It is well accepted by the participants that this second version of the cross-section library is significantly improved and good enough to be used in Exercises 2 and 3. The libraries for scenarios 1 and 2 will be made available to participants by the end of October 2006.

### **Presentation and discussion of results of V1000CT2 Exercise 2**

E. Royer presented the comparative analysis of Main Steam Line Break computations for Exercises 2. For the time being only preliminary results are available, since the cross-section libraries were not finalized.

Steady-state results obtained by Penn State and CEA/INRNE with the new cross sections agree well, particularly for scram rod worth and stuck rod worth. This is a necessary condition for consistent results in the MSLB transient.

Transient results from three participants were compared: FZR with DYN3D/ATHLET, FZK with TRACE/PARCS and CEA/INRNE with CATHARE. This preliminary comparison underlines the need for an accurate and validated mixing model in the reactor pressure vessel. Actually sector-wise core inlet temperatures do not agree very well, and it seems that further investigation of the thermal-hydraulic models is necessary to better understand the differences. It will be the aim of the very detailed questionnaire, to be filled in by participants, in addition to the template when submitting their results.

### **Presentation of participants results for V1000CT2**

Two participants presented their preliminary results: Exercises 1 and 2 by C. Parisi, University of Pisa, and Exercise 3 by K. Velkov, GRS. Both presentations follow the logic of the V1000CT-2 benchmark: the first step is to develop and validate the reactor pressure vessel model against plant data for flow mixing (Exercise 1), and then the simulation of the Main Steam Line Break using vessel boundary conditions (Exercise 2) or full plant model (Exercise 3) is carried out.

**Updating work plan and schedule, actions to progress to complete Phase 2**

The main decisions and actions are:

1. Exercise 1
  - Publish Volume I as soon as possible
2. Exercises 2 and 3
  - Deliver the cross section library version 2
  - Update (core neutronic model) and publish the MSLB Specifications (Volume II),
  - Prepare and distribute the questionnaire (model use / deviation from specification),
  - Adjust the deadlines for submission of results by participants,
  - The possibility of a review paper at M&C + SNA-2007 at Monterey is delayed because the comprehensive analysis will not be ready by that time. Another conference should be envisaged, in addition to the special edition in Nuclear Science and Engineering for such a presentation.

Updated actions and deadlines for V1000CT-2 are summarized in the following table:

Nr.	Action	By whom	Deadline
	Distribute questionnaire for Exercise 1	N. Kolev, E. Royer	30-10-2006
	Prepare and release cross-section library version 2	B. Ivanov	30-10-2006
	Update and finalize MSLB Specifications (Vol. II)	N. Kolev, E. Royer	31-12-2006
	Distribute questionnaire for Exercises 2 and 3	N. Kolev, E. Royer	31-11-2006
	Update template for Exercises 2 and 3	N. Kolev, E. Royer	31-11-2006
	Submit results for Exercises 2	Participants	31-12-2006
	Submit results for Exercises 3	Participants	28-02-2007
	Prepare draft report for Exercise 1 (Vol. III)	N. Kolev, E. Royer	30-04-2007
	Organize final workshop in Paris	Benchmark team	07-05-2006
	Submit papers for NSE special issue	Participants + Benchmark team	30-04-2007

**Proceedings**

The presentations made at the meeting including this summary are available on the cumulative CD-ROM prepared by OECD/NEA, which is being distributed to all benchmark participants.

## **Conclusions**

The meeting was a good opportunity to present the latest activities of both the benchmark team and the participants. The schedule has been updated in order to cope with the new release of the cross-section library. The main actions to complete now in order to finalize the benchmark in 2007 are the submission of the final results for Exercises 2 and 3 and their analysis by the benchmark team. In addition to presentations at international conferences such as NURETH or PHYSOR, it is very valuable to publish the main results in scientific journals. This work is almost completed for V1000CT-1 and will be published in Progress in Nuclear Energy, and the group confirmed their intention to combine a general paper on V1000CT-2 prepared by the benchmark team with papers written by the participants detailing their specific work in a special issue of Nuclear Science and Engineering.

**Annex I**

**OECD/DOE/CEA VVER-1000 COOLANT TRANSIENT BENCHMARK –  
AD-HOC MEETING**

**(V1000-CT4.5)**

Vancouver, Canada

12 September 2006

Hosted by Physor-2006

**AGENDA**[V4.501]

**September 12<sup>th</sup> 8:00 am – 1:00 pm**

8:00-8:30 Introduction and welcome

8:30-9:30 Improved cross-section libraries for Exercises 2 and 3, scenarios 1 and 2

B. Ivanov, K. Ivanov, and N. Kolev : Cross-Section Library 2.0 for MSLB [V4.502]

N. Petrov, N. Kolev, E. Royer, D. Angelova, Comparison of coarse-mesh calculations for V1000CT2 Exercise 2: simulation of MSLB with vessel boundary conditions [V4.503]

9:30-10:30 Comparison of submitted results for Exercise 2 and 3

10:30-12:00 Participants presentations

S. Nikonov, M. Lizorkin, S. Langenbuch, K. Velkov: Validation of Reactor Pressure Vessel Nodalization Applied for ATHLET/BIPR-8KN - Solution of Exercise 3 by Comparison with Plant Mixing Measurement [V4.504a], ([V4.504v1], [[V4.504v2] video clips)

S. Nikonov, M. Lizorkin, A. Kotsarev., S. Langenbuch., K. Velkov: Optimal Nodalization Schemas of VVER-1000 Reactor Pressure Vessel for the Coupled Code ATHLET-BIPR8KN ([V4.04b] paper presented at AER Forum, September 2006)

A. Frisani, C. Parisi, F. D’Auria: “Development of a VVER1000 3D TH-NK model by RELAP5-3D(c) code” [V4.505]

12:00-1:00 Round table and conclusions – Summary [V4.506]

**Annex II**

## List of Participants

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\* apologies for not having been able to attend