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

**17-Feb-2006**

**English - Or. English**

**NUCLEAR ENERGY AGENCY  
NUCLEAR SCIENCE COMMITTEE**

**NEA/NSC/DOC(2006)7  
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**NUCLEAR SCIENCE COMMITTEE  
and  
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS**

**OECD/DOE/CEA VVER-1000 Coolant Transient Benchmark  
(V1000-CT) - 4th Workshop**

**24-25 April 2006  
Pisa, Italy**

**JT00201277**

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**English - Or. English**

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

**OECD/DOE/CEA  
VVER-1000 Coolant Transient Benchmark  
(V1000-CT) – 4<sup>th</sup> Workshop**

Pisa, Italy  
24-25 April 2006

Hosted by  
University of Pisa, Italy

**PROPOSED PROGRAMME**

**OECD/DOE/CEA  
VVER-1000 Coolant Transient Benchmark  
Fourth Workshop (V1000-CT4)**

(Pisa, Italy, 24-25 April 2006)

**Sponsorship**

The fourth workshop for the VVER-CT benchmark will be held on 24<sup>th</sup> and 25<sup>th</sup> April 2005 in Pisa, Italy, and is a follow up to following events: the ad-hoc meeting held during the NURETH-11 conference, Avignon, France, on 4<sup>th</sup> 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).

This workshop is held in conjunction with the Atomic Energy Research (AER) "VVER Dynamics and Safety " Working Group D Meeting, scheduled for 26-27 April 2006 at the same place, in order to facilitate co-ordination and sharing of work. Two other meetings are also held at the same place and during the same week in order to combine efforts in common areas such as Computational Fluid Dynamics (CFD) modelling and uncertainty analysis, and make participation more efficient. These meetings are the third workshop for the OECD/NRC benchmark based on the NUPEC BWR Full-size Fine-mesh Bundle Tests (BFBT-3), scheduled for 26-27 April 2006 (in parallel to the AER Working Group D meeting), and the NEA/OECD meeting on "Uncertainty Analysis in Modelling", scheduled for 28-(29) April 2006.

**Background and Purpose of the Benchmark Workshop**

The Nuclear Energy Agency (NEA) of the Organisation for Economic Cooperation and Development (OECD) has completed, under the sponsorship of the Nuclear Regulatory Commission (NRC), a PWR Main Steam Line Break (MSLB) Benchmark against thermal-hydraulic/neutron kinetics codes. Recently another OECD/NRC coupled code benchmark was completed for a BWR turbine trip (TT) transient. During the course of defining and coordinating the OECD/NRC PWR MSLB and BWR TT benchmarks a systematic approach was established to validate best estimate coupled codes. This approach employs a multi-level methodology that not only allows a consistent and comprehensive validation process but also contributes to determining additional requirements as well as to preparing a basis for licensing application of coupled calculations for a specific reactor type and to developing safety expertise in analyzing reactivity transients. Professional communities have been established during the course of these benchmark activities that allowed in-depth discussions of the different aspects relative to assessing neutron kinetics modeling for a given reactor and the way to implement best-estimate methodologies for transient analysis using coupled codes. The above examples demonstrate the benefit of establishing such international coupled standard problems for each type of reactor.

Further continuation of the above activities is the development of a VVER-1000 coolant transient (V1000CT) benchmark, which defines coupled code standard problems for validation of thermal-hydraulics system codes for application to Soviet-designed VVER-1000 reactors based on actual plant data. The overall objective is to assess computer codes used in the safety analysis of VVER power plants,

specifically for their use in reactivity transients in a VVER-1000. In performing this work the PSU, USA and CEA-Saclay, France, have collaborated with Bulgarian organizations, in particular with the KNPP and the INRNE. The V1000CT benchmark consist of two phases: V1000CT-1 is a simulation of the switching on of one main coolant pump (MCP) when the other three MCPs are in operation, and V1000CT-2 concerns calculation of coolant mixing tests and main steam line break (MSLB) scenarios. Each of the two phases contains three exercises. The reference problem chosen for simulation in Phase 1 is a MCP switching on when the other three main coolant pumps are in operation in a VVER-1000. It is an experiment that was conducted by Bulgarian and Russian engineers during the plant-commissioning phase at the Kozloduy NPP Unit #6 as a part of the start-up tests. The test was done because of its importance for the safety of the VVER-1000 NPP, model 320. The reactor is at the beginning of cycle (BOC) with average core exposure of 30.7 EFPD. At the beginning of the experiment there are three pumps in operation – 1<sup>st</sup>, 2<sup>nd</sup> and 4<sup>th</sup> main coolant pumps and the reactor power is at 27.47% of the nominal power level (824 MWt). The control rod group #10 is inserted into the core. The group position in axial direction is at about 36% withdrawn from the bottom of the reactor core. Analysis of the initial three-dimensional (3-D) relative power distribution showed that this insertion introduced axial neutronics asymmetry in the core. At the beginning of the transient there is also a radial thermal-hydraulic asymmetry coming from the colder water introduced in one quarter of the core when MCP #3 is switched on. This causes a spatial asymmetry in the reactivity feedback, which is propagated through the transient and combined with insertion of positive reactivity. In summary, this event is characterized by a rapid increase in the flow through the core resulting in a coolant temperature decrease, which is spatially dependent. This leads to insertion of spatially distributed positive reactivity due to the modeled feedback mechanisms and non-symmetric power distribution. Simulation of the transient requires evaluation of core response from a multi-dimensional perspective (coupled three-dimensional neutronics/core thermal-hydraulics) supplemented by a one-dimensional simulation of the remainder of the reactor coolant system. Three exercises are defined in the framework of Phase 1:

- a) Exercise 1 – Point kinetics plant simulation;
- b) Exercise 2 – Coupled 3-D neutronics/core thermal-hydraulics response evaluation;
- c) Exercise 3 – Best-estimate coupled 3-D core/plant system transient modeling.

In addition to the measured (experiment) scenario, extreme calculation scenarios were defined in the frame of Exercise 3 for better testing 3-D neutronics/thermal-hydraulics techniques. The proposals concerned: rod ejection simulations with scram set points at two different power levels.

Since the previous coupled code benchmarks indicated that further development of the mixing computation models in the integrated codes is necessary, a coolant mixing experiment and a MSLB scenario are selected for simulation in Phase 2 of the benchmark. The introduction as an additional option of CFD modeling of the vessel with specific boundary conditions rather than core boundary conditions and CFD modeling of the mixing is also included as Exercise 1 of Phase 2. For this specific case additional data from KNPP Unit #6 are made available. The selected mixing experiment was conducted at KNPP #6 as part of the plant commissioning phase. This asymmetric experiment includes single loop cooling and heating-up at 9 % of nominal power with all MCP in operation. It will be used to test and validate vessel-mixing models (CFD, coarse-mesh and mixing matrix). Vessel boundary conditions and core power distribution are part of this exercise specification.

The transient to be analyzed in Phase 2 is initiated by a MSLB in the VVER-1000 NPP between the steam generator and the steam isolation valve, outside of the containment. This event is characterized by a large asymmetric cooling of the core, stuck rods and a large primary coolant flow variation. Two scenarios are defined: the first scenario is taken from the current licensing practice and the second one is derived from

the original one using aggravating assumptions to enhance the code-to-code comparisons. The main objective is to clarify the local 3-D feedback effects depending on the vessel mixing. Special emphasis is put on testing 3-D vessel thermal-hydraulics models and coupling of 3-D neutronics/vessel thermal-hydraulics. The MSLB scenario simulation is divided into two exercises: Exercise 2 consists of coupled 3-D neutronics/vessel thermal-hydraulics simulation using specified vessel thermal-hydraulic boundary conditions, and Exercise 3 consists of best-estimate coupled 3-D core/3-D vessel/plant system modeling. At its annual meeting in Paris in June 2002, the Nuclear Science Committee (NSC) of NEA/OECD, approved and endorsed the developed V1000CT benchmark problem to become an international standard problem for validation of the best-estimate safety codes for VVER applications. Collaboration with the AER Working Group D involved in VVER reactor dynamics and safety on the proposed VVER-1000 coolant transient benchmark is established and the AER participates actively in the benchmark activities. The co-operation of this working group with the V1000CT benchmark group was endorsed by the OECD/NEA NSC, and is supported by the Safety Division. The AER Working Group D meeting will be held from 26 to 27 April, 2006 at the same premises in Pisa, Italy.

### **Scope and Technical Content of the Benchmark Workshop**

The technical topics presented at this workshop are shown below. In addition, the proposed workshop programme is attached as Annex.

- Review of the benchmark activities after the 3<sup>rd</sup> Workshop
- Discussion of participant's feedback and introduced modifications to the Benchmark Specifications
- Presentation and discussion of final results of Phase 1
- Presentation and discussion of final results from Exercise 1 of Phase 2
- Discussion of the Specifications for Exercises 2 and 3 of Phase 2
- Presentation and discussion of preliminary results from Exercises 2 and 3 of Phase 2
- Defining work plan and schedule, actions to progress in completing the 2 phases

### **Organization of the Benchmark Workshop**

The meeting is organized around the discussion of the Specifications of Exercises 2 and 3 of Phase 2, final results for Exercise 1 of Phase 2 and preliminary results for Exercises 2 and 3 of Phase 2. Presentations on related experience in VVER core and system modeling as well as on CFD modeling are encouraged.

### **Participation in the Benchmark Workshop**

For Benchmark Workshops sponsored by the Nuclear Science Committee (NSC) and the Committee on the Safety of Nuclear Installations (CSNI), participation is restricted, for efficiency, to experts (research laboratories, safety authorities, regulatory agencies, utilities, owners' groups, vendors, etc.) from OECD Member countries nominated by delegates to the Committees in consultation with official authorities concerned and with the assistance of members of the Nuclear Science Committee and the Committee on the Safety of Nuclear Installations (information about members are provided as Annex 3 and 4) and in particular to participants in this study.

The meeting is open to experts from Central and Eastern European Countries and the New Independent States of the ex-Soviet Union, who are in a position to provide a substantive contribution to this study. Participation of these experts will be arranged by the NEA Secretariat including participants of AER organizations and Kiev University, Ukraine.

**Organization and Programme Committee of the Benchmark Workshop**

An Organization and Programme Committee was nominated for arranging the Benchmark Workshop, to organise the Sessions, to draw up the final programme, to appoint Session Chairmen, etc. Its members are:

**Francesco D'Auria**

**Chairman**

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**Member of NSC, NEA, OECD**

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**Chairman of Working Group D of AER**

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E-mail: [sartori@nea.fr](mailto:sartori@nea.fr)

### **Proposed Programme of the Benchmark Workshop**

The proposed programme was drawn up by the Programme Committee and is enclosed as Annex 1.

### **Language of the Benchmark Workshop**

The official language of the Fourth Benchmark Workshop is English.

### **Proceedings of the Workshop**

A summary of the Workshop will be published by the OECD as soon as possible after the meeting. The summary will be distributed free of charge to the participants in the Workshop and to delegates of the NSC and CSNI. The programme committee and the session chairmen will prepare a Summary Report on the main results of the meeting for presentation to the NSC Working Party on Scientific Issues in Reactor Systems (WPRS) and CSNI. In addition, copies of presentations will be distributed free of charge to all participants at the meeting.

### **Workshop Location**

Grand Hotel Duomo  
Via S.Maria, 94  
56126 Pisa Italy  
Tel. +39 050 561 894  
Fax +39 050 560 418  
<http://www.grandhotelduomo.it/>

**Local Arrangements**

The organisers propose accommodation at the Grand Hotel Duomo, where the workshop will take place. Registration form for the series of workshops and accommodation can be found as Annex 2.

**Transportation**

The Pisa airport is located at about 5 km from the centre of Pisa. The centre can be reached either by bus or by taxi.

Annex 1

**OECD/DOE/CEA VVER-1000 Coolant Transient Benchmark - Fourth Workshop  
(V1000-CT4)**

Pisa, Italy  
24-25 April 2006

Hosted by: University of Pisa

**PROPOSED PROGRAMME**

**April 24<sup>th</sup>**

**Session 1 – Session Chair** – F. D’Auria

09:00-09:30 Introduction and Welcome

University of Pisa

OECD-NEA

Introduction of Participants

09:30-10:00 Overview of V1000CT1 including PNE special issue – *K. Ivanov*

10:00-10:30 Overview and status of V1000CT2 benchmark – *N. Kolev, E. Royer*

10:30-10:45 Coffee Break

**Session 2 – Session Chair** – P. Siltanen

10:45-11:15 Presentation of final report (Volume IV) for V1000CT1 Exercise 1 – *B. Ivanov*

11:15-12:00 Presentation of final results for V1000CT2 Exercise 1 – *N. Kolev, E. Royer*

12:00-13:30 Lunch

**Session 3 – Session Chair** – E. Popov

13:30-14:30 General presentation of Specifications for V1000CT2 Exercises 2 and 3 (MSLB) – *N. Kolev*

14:30-15:00 Cross-sections libraries for MSLB – *B. Ivanov*

15:00-15:15 Coffee Break

**Session 4 – Session Chair** – S. Langenbuch

15:15-15:45 Boundary conditions for MSLB – *N. Kolev*

15:45-16:15 Requested outputs for MSLB – *E. Royer*

16:15-17:00 Participants’ presentations

- “FLUENT and TRACE Modeling and Results for Exercise 1 of V1000CT2” – *E. Popov*  
(ORNL), *B. Ivanov* and *K. Ivanov* (PSU).

**April 25<sup>th</sup>**

**Session 5 – Session Chair** – E. Royer

09:00-10:45 Participants' presentations

- "TRACE/PARCS Modeling and Results for Exercise 2 of V1000CT2" – B. Ivanov (PSU), *E. Popov (ORNL)*, and *K. Ivanov (PSU)*

10:45-11:00 Coffee Break

**Session 6 – Session Chair** – S. Kliem

11:00-11:30 Presentation of submitted results for V1000CT2 Exercise 2 – *E. Royer*

11:30-12:00 Presentation of submitted results for V1000CT2 Exercise 3 – *N. Kolev*

12:00-13:30 Lunch

**Session 7 – Session Chair** – J. Aragonés

13:30-14:00 Summary of technical issues for MSLB exercises – *N. Kolev*, *E. Royer*

14:00-14:30 Discussion of the schedule and next meetings – *E. Sartori*

14:30-14:45 Conclusion and closing remarks

Annex 2

**OECD/NEA Workshops in Pisa**

Host Organization  
University of Pisa, Italy

**24-29 April 2006**

PARTICIPATION AND HOTEL REGISTRATION FORM

Even if you attend more than one of the following workshops (V1000CT4, BFBT3, AER-WG-D-2006, UAM-2006), please send only one form as soon as possible, and in any case not later than 31 March, 2006, both to:

**Yulia D'Angelo**

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e-mail: [sartori@nea.fr](mailto:sartori@nea.fr)

If you are attending the **AER Working Group D** meeting please send a copy also to Pertti Siltanen  
[Pertti.Siltanen@fortum.com](mailto:Pertti.Siltanen@fortum.com) ; Fax: +358 1045 33403.

Name:

Company or organization:

Address:

E-mail:

Tel:

Fax:

I need an invitation from the organisers to obtain a **visa** to enter Italy (Yes/No)

Please fill in the following table:

<b>Workshop / Date /Contact Person</b>	<b>Attendance / Presentations / Comments - Requests</b>
<b>Fourth V1000CT Workshop (VVER-1000 Coolant Transients) – (V1000-4)</b>  <b>24 – 25 April</b>  <b>Contact person at UNIPI:</b> Alessandro Del Nevo Phone: +39 050 2210 360 Fax: +39 050 2210 384 E-mail: a.delnevo@ing.unipi.it	<i>Will you attend V1000CT-4?</i>
	<i>If so, will you be giving a presentation?</i>
	<i>Please specify titles, authors, and sessions for the presentation(s)</i>
	<i>I shall not attend but send me the summary. (Yes – No)</i>
<b>OECD/NRC Benchmark based on NUPEC BWR - Full-size Fine-mesh Bundle Tests (BFBT) – (BFBT-3)</b>  <b>26 – 27 April</b>  <b>Contact person at UNIPI:</b> Fabio Moretti Phone: +39 050 2210 372 Fax: +39 050 2210 384 E-mail: f.moretti@ing.unipi.it	<i>Will you attend the BFBT-3?</i>
	<i>If so, will you be giving a presentation?</i>
	<i>Please specify titles, authors, and sessions for the presentation(s)</i>
	<i>I shall not attend but send me the summary. (Yes – No)</i>
<b>Workshop / Date /Contact Person</b>	<b>Attendance / Presentations / Comments - Requests</b>
<b>AER Working Group D Workshop (VVER Dynamics and Safety)</b>  <b>26 – 27 April</b>  <b>Contact person at UNIPI:</b> Carlo Parisi Phone: +39 050 2210 374 Fax: +39 050 2210 384 E-mail: c.parisi@ing.unipi.it	<i>Will you attend the AER workshop?</i>
	<i>If so, will you be giving a presentation?</i>
	<i>Please specify titles, authors, and sessions for the presentation(s)</i>
	<i>I shall not attend but send me the summary. (Yes – No)</i>
<b>Expert Group on "Uncertainty Analysis in Modelling"</b>  <b>28 – 29am April</b>  <b>Contact person at UNIPI:</b> Alessandro Petruzzi Phone: +39 050 2210 377 Fax: +39 050 2210 384 E-mail: a.petruzzi@ing.unipi.it	<i>Will you attend this meeting?</i>
	<i>If so, will you be giving a presentation?</i>
	<i>Please specify titles, authors, and sessions for the presentation(s)</i>
	<i>I shall not attend but send me the summary. (Yes – No)</i>

**The workshops will take place at the Grand Hotel Duomo.** A set of **40 rooms** have been pre-reserved. The organising committee will take care of the hotel reservation.

*Do you wish to stay at “Grand Hotel Duomo”?*

*If so, please specify the type of room, check in and check out dates:*

*Type of room (Single or Double):*

*Check in:*

*Check out:*

Alternative hotels are listed herewith for which participants are requested to do their own booking at: [http://www.pisaonline.it/PISA/hotels\\_centro.htm](http://www.pisaonline.it/PISA/hotels_centro.htm)

### **Workshop Location**

Grand Hotel Duomo \*\*\*\*

Via S.Maria, 94

56126 Pisa Italy

Tel. +39 050 561 894 - Fax +39 050 560 418

<http://www.grandhotelduomo.it/>

Single room EURO..120.00

Double room EURO..173.00

### **Other Hotels**

<p><b><i>Albergo Villa Kinzica</i></b> *** 56126 Pisa (PI) - 2, p. Arcivescovado tel: +39 050 560419 - fax: +39 050 551204 <i>Average Price: 99 euro</i></p>	<p><b><i>Albergo La Pace Di Romanelli A. &amp; A. S.N.C.</i></b> *** 56125 Pisa (PI) - 3, viale Gramsci Antonio tel: +39 050 29351, +39 050 48863 fax: +39 050 502266 <i>Average Price: 94 euro</i></p>
<p><b><i>Albergo Roma</i></b> *** 56126 Pisa (PI) - 111, Via Pisano Bonanno Tel: +39 050 554488 <i>Single Room: 70 euro - Double Room: 108 euro</i></p>	<p><b><i>Hotel Alessandro Della Spina</i></b> *** Via Alessandro della Spina, 2/7/9, 56100 - Pisa <a href="http://www.dormireintoscana.it/AlessandroDellaSpina/">http://www.dormireintoscana.it/AlessandroDellaSpina/</a> <i>Single Room: 105 euro - Double Room: 125 euro</i></p>

A map with the location of the hotels and the venue can be found in

<http://www.nea.fr/html/science/transients/mapPisa.pdf>

**Annex 3**(For detailed address information please look up <http://www.nea.fr/add/>)

OECD Nuclear Energy Agency

NSC (NUCLEAR SCIENCE COMMITTEE MEMBERS)

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