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Organisation de Coopération et de Développement Economiques  
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**English - Or. English**

**NUCLEAR ENERGY AGENCY  
NUCLEAR SCIENCE COMMITTEE**

**NEA/NSC/DOC(2006)8  
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**NUCLEAR SCIENCE COMMITTEE  
and  
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS**

**OECD/NRC Benchmark based on NUPEC BWR Full-mesh Bundle Tests (BFBT)  
Third Workshop (BFBT-3)**

**26-27 April 2006  
Pisa, Italy**

**JT00201273**

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Complete document available on OLIS in its original format**

**English - Or. English**

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

**OECD/NRC Benchmark based on NUPEC BWR  
Full-size Fine-mesh Bundle Tests (BFBT)  
Third Workshop(BFBT-3)**

Pisa, Italy  
26-27 April 2006

Hosted by  
The University of Pisa  
Italy

**PROPOSED PROGRAMME**

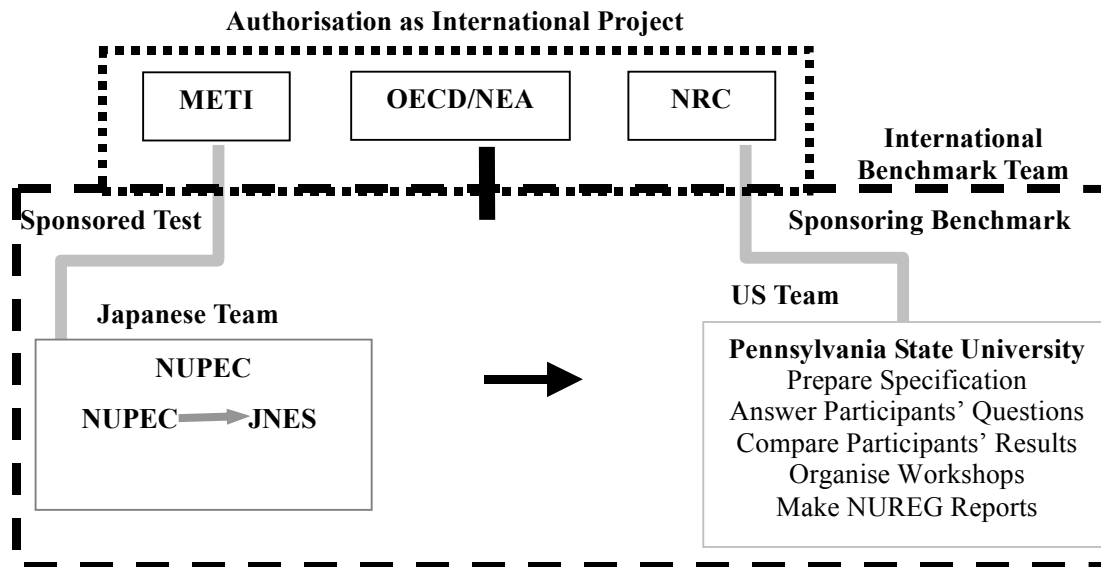
**OECD/NRC Benchmark based on NUPEC BWR  
Full-size Fine-mesh Bundle Tests (BFBT) – Third Workshop  
(BFBT-3)**

Pisa, Italy  
26-27 April 2006

**Sponsorship**

The third workshop for the OECD/NRC Benchmark based on NUPEC BWR Full-size Fine-mesh Bundle Tests (BFBT-3) will be held on 26 and 27 April 2006 in Pisa Italy, and is a follow up to the first and second workshops. The second workshop for the BFBT benchmark (BFBT-2) was held from 27 to 29 June 2005 at State College, PA, USA, and was hosted by the Nuclear Engineering Program (NEP) of the Pennsylvania State University (PSU). The first workshop of the BFBT benchmark (BFBT-1) was held on 4<sup>th</sup> October 2004 and was hosted by the Japan Nuclear Energy Safety (JNES) Organization. The BFBT Benchmark is sponsored by the US Nuclear Regulatory Commission (NRC), the OECD, and the NEP of PSU. The experimental data were produced during a measurement campaign by the NUPEC, Japan and sponsored by the Japan Ministry of Economy, Trade and Industry (METI).

The international benchmark team is organised based on the collaboration between Japan and the USA as shown in the figure below. At the BFBT-2 benchmark workshop CEA-Saclay (France) proposed the introduction of an additional uncertainty analysis exercise to the benchmark and joined the benchmark team in defining and conducting such an exercise.



This workshop (BFBT-3) will be held in conjunction with other meetings, in order to facilitate co-ordination and sharing of work. The two other meetings are being held at the same place and during the same week in order to combine efforts in common areas as CFD modelling and uncertainty analysis and to make participation more efficient. The meetings concerned are the fourth workshop for the OECD/DOE/CEA VVER-1000 Coolant Transient (V1000CT) benchmark – V1000CT-4 – scheduled for

24-25 April 2006, and the NEA/OECD meeting on "Uncertainty Analysis in Modelling", scheduled for 28-(29) April 2006. In parallel with this meeting also the annual meeting of the Working Group D involved in VVER reactor dynamics and safety research is being held at the same premises. For further details please contact Pertti Siltanen, [Pertti.Siltanen@fortum.com](mailto:Pertti.Siltanen@fortum.com).

### **Background and Purpose of the Benchmark Workshop**

In the past decade, a large amount of effort has been made toward the direct simulation of the boiling transition (BT) for BWR fuel bundles. The most advanced sub-channel codes explicitly take into account droplets along with liquid and vapor. They predict the dry-out process as disappearance of the liquid film on the fuel rod surface without employing any semi-empirical correlations. Through a series of benchmark comparisons to full length/scale bundle data, it was verified that the codes are reliable in predicting the critical power of the conventional BWR fuel types. However, these sub-channel codes are not yet utilized in new fuel design. Adequacy of fuel lattice geometries, spacer configurations, etc., has still to be confirmed mainly by costly experiments using partial- and full-scale mock-ups. The main reason for this situation is a shortage of high resolution and full-scale experimental databases under actual operating conditions.

The detailed void distribution inside the fuel bundle is regarded as an important factor in the boiling transition in BWRs. In regard to the sub-channel wise void distribution, it is clear that the flow across the sub-channel gap dominates void distributions. Most of the well-known sub-channel codes still employ the classical Lahey's Void Drift Model or its modified models. Although there have been substantial efforts to establish a sound theoretical background of detailed void distributions, the numerical models that are verified in a wide range of geometrical and thermal-hydraulic conditions are not yet available. In this sense, this subject still remains the major unsolved problem in the two-phase flow of BWR fuel bundles. The main reason for this lack of resolution is the lack of reliable full bundle databases under operating conditions. Up to now, only partial bundle ( $3 \times 3$  or  $4 \times 4$ ) test data under relatively low pressure ( $\approx 1$  MPa) conditions have been made available.

It was during the 4<sup>th</sup> OECD/NRC BWR TT Benchmark Workshop on 6 October 2002 in Seoul, Korea that the need to refine models for best-estimate calculations based on good-quality experimental data was discussed. The needs arising in this respect should not be limited to currently available macroscopic approaches but should be extended to next-generation approaches that focus on more microscopic processes. From 1987 to 1995, NUPEC (Nuclear Power Engineering Corporation) performed a series of void measurement tests using full-size mock-up tests for both BWRs and PWRs. Based on state-of-the-art computer tomography (CT) technology, the void distribution was visualized at the mesh size smaller than the sub-channel under actual plant conditions. NUPEC also performed steady-state and transient critical power test series based on the equivalent full-size mock-ups. Considering the reliability not only of the measured data, but also other relevant parameters such as the system pressure, inlet sub-cooling and rod surface temperature, these test series supplied the first substantial database for the development of truly mechanistic and consistent models for void distribution and boiling transition. Consequently, the basis of this international benchmark is the data made available from the NUPEC database.

This international benchmark encourages advancement in this uninvestigated field of two-phase flow theory with very important relevance to the nuclear reactors' safety margins evaluation. Considering the immaturity of the theoretical approach, the benchmark specification is being designed so that it systematically assesses and compares the participants' numerical models on the prediction of detailed void distributions and critical powers. Furthermore, the following points were kept in mind while establishing the benchmark specification:

- As concerns the numerical model of void distributions, no sound theoretical approach that can be applied to a wide range of geometrical and operating conditions has been developed.

- In the past decade, experimental and computational technologies have tremendously improved though the study of the two-phase flow structure. Over the next decade, it can be expected that mechanistic approaches will be more widely applied to the complicated two-phase fluid phenomena inside fuel bundles.

- The development of truly mechanistic models for critical power prediction is currently underway. These models must include elementary processes such as void distributions, droplet deposit, liquid film entrainment, etc.

The BFBT benchmark is made up of two parts (phases), each part consisting of different exercises:

- Phase I – Void Distribution Benchmark

Exercise 1 (I-1) – Steady-state sub-channel grade benchmark

Exercise 2 (I-2) – Steady-state microscopic grade benchmark

Exercise 3 (I-3) – Transient macroscopic grade benchmark

Exercise 4 (I-4) – Uncertainty analysis of the steady state sub-channel benchmark

- Phase II – Critical Power Benchmark

Exercise 0 (II-0) – Pressure drop benchmark

Exercise 1 (II-1) – Steady-state benchmark

Exercise 2 (II-2) – Transient benchmark

It should be recognized that the purpose of this benchmark is not only the comparison of currently available macroscopic approaches but above-all to encourage the development of novel next-generation approaches that focus on more microscopic processes. Thus, the benchmark problem includes both macroscopic and microscopic measurement data. In this context, the sub-channel grade void fraction data are regarded as the macroscopic data and the digitized computer graphic images are the microscopic data.

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

The technical topics to be addressed at the workshop include:

- Review of the benchmark activities after the 2<sup>nd</sup> Workshop
- Discussion of the final version of the specifications and spacer's dimensions
- Presentation and discussion of modelling issues and comparison of submitted results for Exercise 1 of Phase I (I-1)
- Presentation and discussion of modelling issues and comparison of submitted results for Exercise 2 of Phase I (I-2)
- Presentation and discussion of modelling issues and comparison of submitted results for Exercise 0, Phase II (II-0)
- Presentation and discussion of modelling issues and comparison of submitted results for Exercise 1, Phase II (II-1)
- Discussion of the requested output and templates for submitting results for Exercises 3 and 4 of Phase I (I-3 and I-4), and Exercise 2 of Phase II (II-2)
- Discussion of Exercise 4 of Phase I (uncertainty analysis of I-1) and discussion of the introduction of Exercise 3 of Phase II (II-3) – uncertainty analysis of II-1
- Defining a work plan and schedule outlining actions to progress the two phases of the benchmark activities

The proposed workshop programme is attached as Annex 1.

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

The meeting is organized around the discussion of the final Benchmark Specifications, as well as presentation and discussion of modelling issues and submitted results for Exercises I-1 and I-2, II-0, and II-1. At the second workshop of the OECD/NRC BFBT Benchmark – BFBT-2 a schedule for benchmark activities was accepted by the participants of the Workshop (see NEA/NSC/DOC (2005)19). The Final Specification, which took into account all the comments and suggestions of the BFBT-2 workshop, was distributed in November 2005. The participants are requested to present their **modelling and results**, for any of the exercises of both phases at the 3<sup>rd</sup> Workshop. Presentations on related experience in BWR sub-channel modelling as well as on CFD modelling are also encouraged.

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

For Benchmark Workshops sponsored by the Nuclear Science Committee (NSC) and Committee on the Safety of Nuclear Installations (CSNI), participation is restricted, for efficiency, to participants in this study and 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).

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

An Organization and Programme Committee has been nominated to make the necessary arrangements for the Third Benchmark Workshop and to organize the Sessions, draw up the final programme, appoint Session Chairmen, etc. Its members are:

**Francesco D'Auria (Chairman)**

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Tel : +33 1 4524 1072, Fax :+33 (1) 4524 1110  
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 Third Benchmark Workshop is English.

### **Proceedings of the Workshop**

A summary of the Workshop will be published by the OECD/NEA 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 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/NRC Benchmark based on NUPEC BWR  
Full-size Fine-mesh Bundle Tests (BFBT) – Third Workshop  
(BFBT-3)**

Hosted by the  
University of Pisa, Italy  
26-27 April 2006

**PROPOSED PROGRAMME**

**Day 1: 26 April 2006**

1. Introduction and opening remarks
2. Overview and status of benchmark activities

***Technical Sessions on Phase I – Void Distribution Benchmark***

3. Summary of the major additions and modifications in the final BFBT benchmark specification
4. Discussion of the estimation of spacer's grid dimensions and effect of the individual sub-channel loss coefficients
5. Evaluation of the void distribution measured data included in Exercise I-1
6. Summary of comparison and analysis of submitted results for Exercise I-1
7. Summary of comparison and analysis of submitted results for Exercise I-2
8. Presentation on an optimization approach of void distribution calculation for improved agreement with measured data
9. Participants' presentations on modelling and results for Exercises I-1 and I-2
10. Presentation on related topics from participants – BWR sub-channel modelling, CFD modelling,
11. Discussion of modelling issues and preliminary results for Exercise I-3.
12. Presentation on an approach for uncertainty propagation and analysis (Exercise I-4)
13. Discussion of the requested output, templates for submitting results, and sample results for Exercises I-3 and I-4.
14. Discussion on Phase I

**Day 2: 27 April 2006**

***Technical Sessions on Phase 2 – Critical Power Benchmark***

15. Summary of comparison and analysis of submitted results for Exercise II-0
16. Summary of comparison and analysis of submitted results for Exercise II-1
17. Participants' presentations on modelling and results for Exercises II-0 and II-1
18. Presentations on related topics from participants
19. Presentation and discussion of the modelling issues and preliminary results for Exercise II-2
20. Discussion of the requested output, templates for submitting results, and sample results for Exercise II-2
21. Discussion of the introduction of Exercise 3 of Phase II (II-3) – uncertainty analysis of II-1, and definition of such exercise
22. Discussion on Phase 2
23. Action items and schedule of benchmark activities
24. Next workshop (BFBT-4) and plans
25. Conclusions 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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**Enrico Sartori**

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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 href="mailto:a.delnevo@ing.unipi.it">a.delnevo@ing.unipi.it</a>	<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: <a href="mailto:f.moretti@ing.unipi.it">f.moretti@ing.unipi.it</a>	<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>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: <a href="mailto:c.parisi@ing.unipi.it">c.parisi@ing.unipi.it</a>	<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 href="mailto:a.petruzzi@ing.unipi.it">a.petruzzi@ing.unipi.it</a>	<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

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**Annex 4**(For detailed address information please look up <http://www.nea.fr/add/>)

OECD Nuclear Energy Agency

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