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**NUCLEAR ENERGY AGENCY
NUCLEAR SCIENCE COMMITTEE**

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**OECD/NRC Benchmark based on NUPEC BWR
Full-size Fine-mesh Bundle Tests (BFBT)
Sixth Workshop (BFBT-6)**

PROPOSED PROGRAMME

**University Park / State College, PA, USA
April 27-28, 2009**

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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)
Sixth Workshop (BFBT-6)**

In memory of late Prof. L. Hochreiter

University Park / State College, PA, USA
April 27-28 2009

Hosted by
The Pennsylvania State University (PSU)
USA

PROPOSED PROGRAMME

**OECD/NRC Benchmark based on NUPEC BWR
Full-size Fine-mesh Bundle Tests (BFBT) – Sixth Workshop
(BFBT-6)**

University Park / State College, PA, USA
April 27-28, 2009

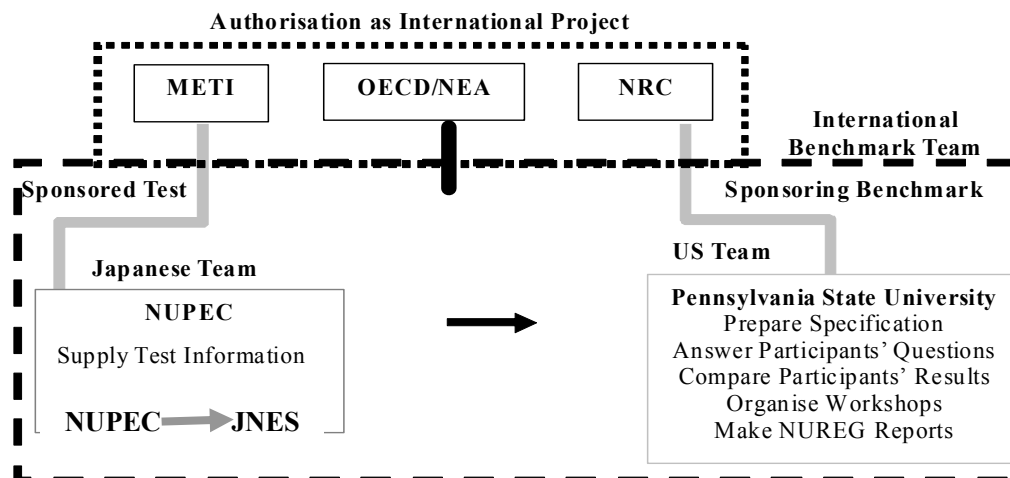
Sponsorship

The Sixth workshop for the OECD/NRC Benchmark based on NUPEC BWR Full-size Fine-mesh Bundle Tests (BFBT-6) will be held on April 27-28 2009 in University Park / State College, PA, USA, and is a follow up to the first five workshops:

1. First workshop (BFBT-1) held on 4 October 2004, hosted by the Japan Nuclear Energy Safety (JNES) Organisation;
2. Second workshop, (BFBT-2) held from 27 to 29 June 2005 at State College, PSA, USA, hosted by the Nuclear Engineering Program (NEP) of the Pennsylvania State University (PSU);
3. Third workshop (BFBT-3) held on 26 and 27 April 2006, at Pisa, Italy, hosted by the University of Pisa.
4. Fourth workshop (BFBT-4) held on 8 and 9 May 2007 in Paris, France, hosted by CEA-Saclay and OECD/NEA.
5. Fifth workshop (BFBT-5) held on 31 March and 1 April 2008 in Garching, Germany, hosted by GRS mbH.

The BFBT-6 workshop is dedicated to Dr. Lawrence E. Hochreiter, Professor of Nuclear and Mechanical Engineering, to commemorate his contributions to the field of nuclear reactor thermal-hydraulics and safety.

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, 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-6) 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 such as CFD modelling and uncertainty analysis and to make the participation more efficient. The meetings concerned are the Third Workshop for the OECD Uncertainty Analysis in Modelling (UAM) Light Water Reactor (LWR) benchmark UAM-3, scheduled for April 29 - May 1 2009; in parallel with the BFBT-6 meeting also the First OECD Kalinin-3 VVER-1000 Benchmark Workshop is being held at the same premises. There will be a special session on LWR UAM in multi-physics multi-scale simulations at the M&C 2009 Conference in Saratoga Springs, NY, USA (6 hours drive from PSU). The M&C 2009 conference will take place on May 3-7, 2009 (the week after the Benchmark workshops at PSU).

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. With 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, the subject still remains the major unsolved problem in the two-phase flow of BWR fuel bundles. The main reason is the lack of reliable full bundle databases under operating conditions. Up to now, only partial bundle (3×3 or 4×4) test data under relatively low pressure (≈ 1 MPa) conditions have been made available.

It was during the 4th 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 the uninvestigated fields 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

Exercise 3 (II-3) – Uncertainty analysis of the steady critical power benchmark

It should be recognized that the purpose of this benchmark is not only to compare 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 5th Workshop
- Discussion of the report on Phase I
- Participants' presentations on their models and results for Exercises I-1, I-2 and I-3
- Discussion of the report on Phase II
- Participants' presentations on their models and results for Exercises II-0, II-1 and II-2
- Presentation and discussion of the results submitted for the uncertainty analysis exercises

- Participants' presentations on their models and results for Exercises I-4 and II-3
- Introduction and presentation of the new OECD benchmark based on NUPEC PWR Sub-channel and Bundle Tests (PSBT) (as follow-up benchmark activities of the OECD/NRC BFBT benchmark): database, specification and schedule.
- Status of the NED special issue with participants' BFBT papers
- 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 results on uncertainty analysis exercises (I-4 and II-3), as well as presentation and discussion of the reports summarizing the results for Exercises I-1, I-2, I-3, II-0, II-1, and II-2. At the fifth workshop of the OECD/NRC BFBT Benchmark – BFBT-5 a schedule for benchmark activities was accepted by the participants of the Workshop (see NEA/NSC/DOC (2008)5). The participants are requested to present their modelling and results, for any of the exercises of both phases at the 6th Workshop. Presentations on related experience in BWR and PWR 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 Sixth Benchmark Workshop and to organize the Sessions, draw up the final programme, appoint Session Chairmen, etc. Its members are:

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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 Sixth 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

The Sixth workshop will take place in University Park / State College, Pennsylvania (located in the Happy Valley) – home of PSU. For the State College Airport (SCE) there are flight connections from Washington DC (United), Philadelphia (US Air) and Detroit (Northwest). State College is at 2 and 1/2 hours drive from Pittsburgh, 3 and 1/2 hours drive from Philadelphia, 4 hours drive from Washington DC and 5 hours drive from New York City.

Local Arrangements

The organisers propose accommodation at the hotels in State College, which will be managed by:

Donna M. Gensimore
Administrative Support Assistant
Dept. Mechanical and Nuclear Engineering
336-C Reber Building
(814) 865-5947
FAX: (814) 863-4848
E-mail: dmgl@enr.psu.edu

Please fill the registration form for the series of workshops and accommodation, which can be found as Annex 2.

Transportation

At the State College Airport there is taxi and shuttle transportation available to hotels and downtown.

Annex 1

**OECD/NRC Benchmark based on NUPEC BWR
Full-size Fine-mesh Bundle Tests (BFBT) – Sixth Workshop
(BFBT-6)**

Hosted by
The Pennsylvania State University (PSU), Germany
April 27-28 2009

PROPOSED PROGRAMME

Day 1: 27 April 2009

1. Introduction and opening remarks
2. Remembering late Prof. L. Hochreiter
3. Overview and status of benchmark activities

Technical Sessions on Phase I – Void Distribution Benchmark

4. Discussion of rod displacement issue
5. Discussion of updated densitometer correlation
6. Presentation of the report on Phase I
7. Discussion of the report on Phase I
8. Participants' presentations on their models and results for Exercises I-1, I-2 and I-3
9. Summary of comparison and analysis of submitted results for Exercise I-4.
10. Participants' presentations on modelling and results for Exercise I-4.
11. Presentations on related topics from participants – BWR sub-channel modelling, uncertainty analysis and CFD modelling.
12. Discussion on Phase I

Day 2: 1 April 2008

Technical Sessions on Phase 2 – Critical Power Benchmark

13. Presentation of the report on Phase II
14. Discussion of the report on Phase II

15. Participants' presentations on their models and results for Exercises II-0, II-1 and II-2
16. Summary of comparison and analysis of submitted results for Exercise II-3.
17. Participants' presentations on modelling and results for Exercise II-3.
18. Presentations on related topics from participants – pressure drop and critical power modelling
19. Discussion on Phase 2
20. Introduction and presentation of the new OECD benchmark based on NUPEC PWR Sub-channel and Bundle Tests (PSBT) (as follow-up benchmark activities of the OECD/NRC BFBT benchmark):
 - a. Benchmark database,
 - b. Benchmark specification
 - c. Benchmark schedule.
21. Presentations from participants on PWR sub-channel and CFD modelling
22. Action items and schedule of benchmark activities – report on the BFBT uncertainty analysis exercises First workshop (PSBT-1) and plans
23. Conclusions and closing remarks
24. Visit to Rod Bundle Heat Transfer Facility and Advanced Multi-Phase Flow Laboratory at PSU

Annex 2

OECD/NEA Workshops in University Park / State College, PA, USA

**OECD/NRC BFBT Benchmark – Sixth Workshop
(BFBT-6)**

Host Organization
The Pennsylvania State University (PSU), USA
April 27-28, 2009

PARTICIPATION AND HOTEL REGISTRATION FORM

Even if you attend more than one of the following workshops (BFBT-6, Kalinin-2009, UAM-3), please send only one form as soon as possible, and in any case not later than April 14, 2009, both to:

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E-mail: sartori@nea.fr

Name:

Company or organization:

Address:

E-mail:

Tel:

Fax:

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

Please fill in the following table:

Workshop / Date /Contact Person	Attendance / Presentations / Comments – Requests
Sixth workshop of the OECD/NRC Benchmark based on NUPEC BWR – Full-size Fine-mesh Bundle Tests (BFBT) – (BFBT-6)	<i>Will you attend BFBT-6?</i>
	<i>If so, will you be giving a presentation?</i>
	April 27-28
	<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>
First OECD Kalinin-3 Coupled Code Benchmark (Kalinin-2009)	<i>Will you attend the Kalinin-2009 workshop?</i>
	<i>If so, will you be giving a presentation?</i>
	April 27-28
	<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>
Third workshop for the OECD Uncertainty Analysis in Modelling (UAM) Light Water Reactor (LWR) benchmark – (UAM-3)	<i>Will you attend the UAM-3?</i>
	<i>If so, will you be giving a presentation?</i>
	April 29 – May 1
	<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>

Accommodation is proposed at the following hotel Atherton Hotel – within walking distance from the workshops' location. 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 Atherton Hotel.?

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:

Other Hotels

A map with the location of the hotels and the venue can be found at <http://www.pahotels.com/cities/State-College/>

Workshop Location

The three workshops will take place in the same building in University Park (the campus) – Reber Building Rooms 135, 125 and 214 and in the conference rooms of Atherton Hotel.

The exact location can be found at <http://www.campusmaps.psu.edu/buildings/reber.shtml>

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

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