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**NUCLEAR ENERGY AGENCY**
**NUCLEAR SCIENCE COMMITTEE**

**OECD/NEA/NSC PBMR COUPLED NEUTRONICS/THERMAL HYDRAULICS TRANSIENT BENCHMARK - THE PBMR-400 CORE DESIGN**

**Proposed Programme of the Third Workshop  (PBMRT3)**

**1-2 February 2007**
**NEA Headquarters, Issy les Moulineaux, France**

**JT03219816**

**OECD/NEA/NSC**
**PBMR COUPLED NEUTRONICS/THERMAL HYDRAULICS TRANSIENT BENCHMARK**
**THE PBMR-400 CORE DESIGN– 3rd Workshop**
**(PBMRT3)**

OECD/NEA Headquarters
12 boulevard des Iles, 92130 Issy les Moulineaux, France
1-2 February 2007

**Background and Purpose of the Benchmark Workshop**

The Nuclear Energy Agency (NEA) of the Organisation for Economic Cooperation and Development (OECD) has accepted, through the Nuclear Science Committee (NSC), to include in its programme the Pebble-Bed Modular Reactor (PBMR) coupled neutronics/thermal hydraulics transient benchmark problem.

The PBMR is a High-Temperature Gas-cooled Reactor (HTGR) concept being developed to be built as a demonstration plant in South Africa. The deterministic neutronics, thermal-hydraulics and transient analysis tools and methods available to design and analyse PBMRs have, in many cases, lagged behind the state-of-the-art compared to other reactor technologies. This has motivated both the testing of existing methods for HTGRs, and the development of more accurate and efficient tools to analyse the neutronics and thermal-hydraulic behaviour for the design and safety evaluations of the PBMR. Both tasks require the definition of appropriate benchmarks to verify and validate the existing and new methods in computer codes.

The first workshop for the Coupled Neutronics/Thermal Hydraulics Transient Benchmark - the PBMR-400 Core Design, was held on 16 and 17 June 2005 at the OECD Headquarters in Paris, France, with the support of the Nuclear Science Committee (NSC) of the NEA of OECD and under the supervision of the Working Party on Scientific Issues in Reactor Systems (WPRS).

At the first workshop, the need for code-to-code validation in HTR methods and software was noted. The PBMR 400MW benchmark test cases were introduced in detail including the neutronic and thermal hydraulic design and data. The three steady-state cases and the six different transient cases, which are the main focus area of the benchmark, were discussed. The details of the meeting are available in NEA/NSC/DOC(2005)13. Other aspects that attracted some attention included the cross section library with leakage feedback options and the fuel temperature calculation methodology during fast reactivity insertion. Finally the future possibilities of benchmarks against experimental or plant data were explored by including presentations on the AVR and HTR-10 reactors.

An ad-hoc lunchtime meeting was also held on 13 September 2005 (PBMRT1.5) during the M&C2005 conference in Avignon, France. At this meeting the benchmark was further promoted and specific aspects of the benchmark definition were discussed. Most of the time was spent on the cross section model to be employed and more specifically whether the pre-tabulated cross sections data should be dependent on the leakage.

The second workshop took place on 26 and 27 January 2006 at the OECD/NEA Headquarters. The details of the meeting are available in NEA/NSC/DOC(2006)29. Presentation of the status of work related to the PBMR benchmark was presented by ten participants. The information presented varied from details of the methods and codes employed to the results obtained for the steady-state cases. The improvements in the benchmark definition (clarifications and additions) were also discussed. The multi-dimensional cross

sections tables and the difficulties experienced with the generation of cross sections based on MICROX-2 (for the range of buckling terms required) was explained and the alternative method, to use the Spectrum code pre-processor of TINTE, was proposed and finally accepted. The focus of the meeting was the steady-state results for Cases 1 (neutronics) and Case 2 (thermal hydraulics). Comparisons were made between the different participants and some discrepancies were identified, including mesh effects, differences in k-eff, misinterpretation of definitions (outlet pressure, temperatures) and interpretations of the requested results (mesh for reporting, power densities, geometrical range used for averaging). Some of the differences seen could be resolved immediately but others required more detailed analysis or re-evaluation. Participants were requested to submit all updated results by April 2006.

A special session was organised at the PHYSOR 2006 conference held in Vancouver, Canada during September 2006. Feedback from this session will be given at the PBMR3.0 meeting (see below).

The third workshop is scheduled for 1-2 February 2007 at the OECD/NEA Headquarters, Room A, 12 boulevard des Iles, 92130 Issy-les-Moulineaux, France. This document contains the announcement, detailed scope and proposed programme for the meeting.

**Sponsorship**

The third workshop for the Coupled Neutronics/Thermal Hydraulics Transient Benchmark - the PBMR-400 Core Design, will be held on 1 and 2 February 2007 at the OECD/NEA Headquarters, Issy-les-Moulineaux, France, with the support of the Nuclear Science Committee (NSC) of the NEA of OECD and under the supervision of the Working Party on Scientific Issues in Reactor Systems (WPRS).

**Scope and Technical Content of the Benchmark**

The scope of the benchmark is to establish a well-defined problem, based on a common given set of cross sections, to compare methods and tools in core simulation and thermal hydraulics analysis with a specific focus on transient events through a set of multi-dimensional computational test problems.

In addition, the benchmark exercise has the following objectives:

- Establish a standard benchmark for coupled codes (neutronics/thermal-hydraulics) for PBMR design;
- Make a code-to-code comparison using a common cross section library – important for Verification and Validation;
- Obtain a detailed understanding of the events and the processes;
- Benefit from different approaches, understanding limitations and approximations;
- Organize a special session at conference/special issue of publication (good exposure)

**Scope and Technical Content of the 3rd Workshop (PBMRT3)**

The focus of the third workshop is as follows:

1. Update on status of the benchmark and the future plans
   The meeting will be used to inform participants of any updates, changes or clarifications made in the benchmark definition. For example, the long awaited final cross section tables for the transient cases, made available in November, will be explained including the definitions for the transport cross sections

that have been added. Some detail on the tests performed and the comparisons made with the polynomial cross section approach used in TINTE (FZJ code used at PBMR) will be shown.

2. Steady State results updates and re-analysis
From the results presented at the 2$^{nd}$ benchmark meeting and the updated results received and presented at PHYSOR2006, it is clear that some discrepancies still remain. Some time will be allocated at the meeting to try and resolve this problem. The latest steady-state Case 1 and Case 2 comparison spreadsheets are available on the benchmark web site for all to download, study and to enable direct comparisons if own results are updated. Updated results must be sent in before 15 January 2007 to facilitate comparisons at the meeting. The aim will be to finalize these two cases at this meeting.

3. New Analysis for next meeting (First attempts)
   a) Make first comparisons on the steady-state (Exercise 3) coupled neutronics – thermal hydraulics case (that includes full neutronic-thermal-hydraulic feedback).
   b) If possible perform Transient cases 1-3 that focus primarily on heat transfer and decay heat phenomena (loss of forced cooling / depressurization).
   If possible results should be submitted by 15 January 2007.

The focus on the test cases will thus be to finalize the two steady-state cases (Exercise 1-2), perform detailed analysis on the coupled steady-state exercise 3, and to compare first results on the transient exercises 1-3.

The workshop also has the following general aims and objectives:
  • Obtain feedback from participants on benchmark implementations into their codes and methods
  • Discuss and coordinate the organization of future special conference sessions on the benchmark (suggestions, organization, plans, publications)
  • Consider specific technical issues of the benchmark such as cross sections, correlations and formats of results
  • Further participants' knowledge and experience on HTR and specifically pebble-bed reactors through discussions and peer reviews

The proposed meeting programme is attached as Annex I.


**Participation in the Benchmark Workshop**

Participation in the Benchmark Workshop is sponsored by the Nuclear Science Committee (NSC), and is restricted, for efficiency, to experts (research laboratories, safety authorities, regulatory agencies, utilities, owner 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 (information about members is provided as Annex II) and in particular to participants in this study.

The meeting is open also to experts from IAEA member countries, who are in a position to provide a substantive contribution to this study. Participation of these experts will be arranged by the NEA Secretariat and includes participants involved in the Gen-IV International Forum VHTR studies.

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

An Organization and Programme Committee is proposed 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 proposed members are:

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## Proposed Programme of the Third Benchmark Workshop

The proposed program is included as Annex I.

## 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 after the meeting and distributed to the participants in the Workshop. The programme committee and the session chairmen will prepare a Summary Report on the main results of the meeting for presentation to the NSC. In addition, copies of presentations will be distributed free of charge to all participants at the meeting.

## Workshop Location / Local Arrangements / Transportation

OECD/NEA Headquarters, Room A, 12 boulevard des Iles, 92130 Issy les Moulineaux, France. (Participants are requested to produce an identity card with a photograph in order to be able to enter the OECD/NEA premises.)

A map of the location, hotel accommodation and transport can be found by accessing the following Web pages http://www.nea.fr/html/general/hotels.html and http://www.nea.fr/html/general/nea-access.html The public transportation network provides easy access from many Paris areas. For additional information check http://www.paris.org/Metro/.

Annex I

**OECD/NEA/NSC**
**PBMR COUPLED NEUTRONICS/THERMAL HYDRAULICS TRANSIENT BENCHMARK**
**THE PBMR-400 CORE DESIGN– 3rd Workshop**

OECD/NEA Headquarters
12 boulevard des Iles
92130 Issy-les-Moulineaux, France
1 – 2 February 2007

**PROPOSED PROGRAMME**

**Day 1:  1 February 2007**

 I. General Session (Chair: F. Reitsma)
    1.  09:15 – 09:30 Introduction and opening remarks – introduction of participants
    2.  09:30 – 09:35 Adoption of agenda
    3.  09:35 – 10:20 Feedback on Benchmark Specification updates and PBMRT2.0 meeting

    10:20 – 10:45 Break

 II.  Feedback by all participants I (Chair: E. Sartori )
    4.  10:45 – 12:45 Presentations from all participants on progress and results.

    12:45 – 14:00 Lunch

 III.  Feedback by all participants II (Chair: H. D. Gougar)
    5.  14:00 – 16:00 Presentations from all participants on progress and results.
        a.  Feedback on special session at PHYSOR2006 (Summary)

    16:00 – 16:20 Break

 IV. Benchmark Steady State Cases (Chair: TBD)
    6.  16:20 – 17:30 Steady State Test case 1 & 2 (K. Ivanov / F. Reitsma)
        a.  Clarification
        b.  Summary of all updated results received
        c.  Comparisons
        d.  Discussion of results

**Day 2: 2 February 2007**

 V. Cross section library (Chair: TBD)
    7.  08:30 – 09:30
        a.   Update of status of supplied library and tests performed

VI. Steady State Test Case 3 / Starting condition of transient cases (Chair: TBD)

8. 09:30 – 10:00 Steady State Test Case 3 / Starting condition of transient cases
   a. Definition
   b. Summary of all results received
   c. Comparisons and analysis of preliminary results of Exercise 3 (K. Ivanov)
   d. Discussion of results
   e. Finalization of Test cases / additional work (All)

   10:00 – 10:20 Break

VI. Transient Cases (Chair: TBD )
   9. 10:20 – 11:00 Transient cases definitions (update & clarifications) (H. Gougar)
   10. 11:00 – 12:30 Preliminary Results of Transient cases

   12:30 – 13:45 Lunch

VII. Transient cases (Chair. TBD )
   11. 13:45 – 14:15 Transient Cases on HTR-10 in CRP5 (results and lessons learned)
   12. 14:15 – 14:40 Specific issues on transient cases

   14:40 – 15:00 Break

VIII. Discussion and closing (Chair: F. Reitsma)

   13. 15:00 – 16:00 Discussion of future actions, Special sessions at conferences / journal and schedule
   14. 16:00 – 16:15 Discussion of next meeting and deliverables
   15. 16:15 – 16:30 Any other business and closure of meeting

NUCLEAR SCIENCE COMMITTEE

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OECD/NEA Headquarters, Issy les Moulineaux, France
1 – 2 February 2007

*PARTICIPANT REGISTRATION FORM*

To be sent as soon as possible, and by Monday 15 January 2007, to

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Name:

Organization:

Address:


E-mail:

FAX:


I shall attend the Coupled Neutronics/Thermal Hydraulics Transient Benchmark - The PBMR-400 Core Design Benchmark Workshop _____
If you are attending, will you be giving a presentation on Day 1 (Presentations from participants - focus on development of PBMR model and / or results, 15-20 minutes)? _____
If yes, what is the title of this presentation and authors?



I will not attend but send me a summary _____

Additional Comments:

# Annex II

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

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