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**NUCLEAR ENERGY AGENCY
NUCLEAR SCIENCE COMMITTEE**

**NEA/NSC/DOC(2008)7
Unclassified**

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

Fourth Workshop (PBMRT4)

**21-25 January 2008
NEA Headquarters, Issy-les-Moulineaux, France**

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Complete document available on OLIS in its original format**

English text only

NUCLEAR SCIENCE COMMITTEE

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

NEA Headquarters, Issy-les-Moulineaux, France
21-25 January 2008

SUMMARY RECORD

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Background and Status of the Benchmark

In 2004 the Nuclear Energy Agency (NEA) of the Organisation for Economic Cooperation and Development (OECD), through the Nuclear Science Committee (NSC), accepted the Pebble-Bed Modular Reactor (PBMR) coupled neutronics/thermal hydraulics transient benchmark problem for inclusion in its programme. The PBMR is a High-Temperature Gas-cooled Reactor (HTGR) concept, developed for construction in South Africa. The scope of the benchmark is to establish a series of well-defined multi-dimensional computational benchmark problems with a common given set of cross-sections, to compare methods and tools in coupled neutronics and thermal hydraulics analysis with a specific focus on transient events.

Similar efforts of pebble bed reactor transient analysis code-to-code comparisons and benchmarking include the PBMR 268MW benchmark problem that served as the predecessor to this exercise, and the work carried out under the IAEA CRP-5 project (TECDOC in preparation). The OECD benchmark includes additional steady-state and transient cases including reactivity insertion transients. Furthermore, it makes use of a common set of cross sections (to eliminate uncertainties between different

codes) and includes specific simplifications to the design to limit the need for participants to introduce approximations in their models. It has also attracted wide participation.

The first workshop was held on 16-17 June 2005 at the OECD Headquarters, Paris, France (NEA/NSC/DOC(2005)13). The purpose of the first workshop was to introduce participants to the benchmark exercise, obtain feedback on the benchmark definition and to establish the possible range of methods and codes to be used in the code-to-code comparisons. The workshop was attended by 24 participants from 12 countries and 20 different organizations. It was also important to establish which experiments might be available to include in later phases of the benchmark effort. Therefore, presentations on the AVR and on past, current, planned, and potential experiments at the HTR-10 reactor were of great interest in identifying possible future test cases with experimental data.

The second workshop took place on 26-27 January 2006 at the OECD/NEA Headquarters. The details of the meeting are available in NEA/NSC/DOC(2006)29. Presentation on the status of work related to the PBMR benchmark were 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-section tables and the difficulties experienced with the generation of cross-sections based on MICROX-2 (for the range of buckling terms required) were explained. An alternative method, to use the spectrum code pre-processor of TINTE, was proposed and accepted. The focus of the meeting was a summary of the steady-state results for Case 1 (stand-alone neutronics) and Case 2 (stand-alone thermal hydraulics). Comparisons were made by 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 found could be resolved immediately but others required more detailed analysis or re-evaluation. The workshop was attended by 25 participants from 7 countries representing 16 different organizations.

A special session was organised at the PHYSOR 2006 conference held in Vancouver, Canada during September 2006. In total five presentations were included in the special session.

The third workshop, held on 1-2 February 2007 (NEA/NSC/DOC(2007)11), finalized all changes and suggestions on the benchmark specification. The changes or clarifications made to the benchmark definition were discussed and finalized, and, once implemented, the updated steady-state results were compared and analysed. It was clear that some discrepancies still remained. To facilitate the resolution of these differences a questionnaire was drawn up to be completed by all participants when submitting their results. This questionnaire contained specific questions to try and ensure the appropriateness of the results and included questions on convergence, mesh refinements, coupling schemes and implementation of the cross-section libraries and defined correlations. Any additional assumptions or approximations made must also be listed. These exercises led to significant improvements in the results

Scope of the 4th Benchmark Workshop

The fourth workshop was held from 21-25 January 2008, with the following scope:

PART I: Workshop on the DIREKT code system (21-23 January 2008)

A 3-day workshop was presented as Part I of the OECD PBMR400 benchmark meeting. The DIREKT code, under development at the Research Centre Jülich (FZJ) in Germany, is able to model steady-state and transient pebble bed reactor thermal hydraulics.

PART II (24 – 25 January 2008)

The 2-day meeting was held to discuss the OECD PBMR-400 Benchmark transient. The focus areas were as follows:

1. Steady State results finalization

The final results sent for the steady-state cases were represented and discussed to facilitate the final comparisons at the meeting. The aim is to publish all the steady-state results in a PHYSOR-2008 summary paper after this meeting.

2. Transient Results

The focus of the workshop was the comparisons of all the transient results. Exercises 1 to 6 results were presented and discussed.

The meeting programme is included in Annex I. The workshop was attended by 18 participants from 8 countries representing 11 different organizations with the list of participants in Annex II

PART I: DIREKT Workshop

DIREKT is a computer program for the time-dependent, two-dimensional simulation of thermal-hydraulic transients in gas cooled reactors and in particular for pebble bed reactors. The program DIREKT is divided into two main modules as described below.

1. The solids module calculates the conservation of the energy equation for steady-state or time dependent situations for all solid areas and stationary fluids. Extensive data libraries are included for the thermal conductivity, heat capacity and heat transfer by means of convection. In the model implementation radiation is considered as part of the effective thermal conductivity in the energy equation. An iterative single-step procedure is applied as the solution procedure for the resulting solids-temperature field.

2. The coupling is made between the solids module and the convection module via the solid temperatures field. From this, the further calculation of gas temperatures and heat transfer is made. The convection module calculates the conservation equations for continuity, momentum and energy for steady-state, quasi-static or transients for a selected fluid flow. A closed solution procedure is used to calculate the resulting fields for relative pressure and fluid temperature by means of a direct matrix solution algorithm.

Examples of the application of the code include

- (i) Steady-state conditions in pebble bed reactors,
- (ii) Starting from stationary operating conditions different transients can be modelled,
- (iii) The program is specifically designed to calculate very quick pressure relief operations in the primary circuit of gas cooled nuclear reactors and
- (iv) Calculation of natural convection processes in closed systems, and free convection currents (fire flow), and finally, since extensive expansion of the libraries were made, calculations on the behaviour of core melts or heavy water cooled reactor concepts can also be investigated.

The workshop focused on the code status and features. Models related to the PBMR 400 OECD Benchmark problem were set up and analysed during the workshop using a hands-on approach. The PBMR400 steady-state exercise 2 case was set up and run successfully with refinements still being made to the model to include these results in the official benchmark set. Discussions also included possible coupling with other codes. The course material was provided and PC's were supplied where the software could be loaded and executed.

PART II: Meeting on OECD Benchmark Progress

The technical topics presented at this fourth workshop are shown below per session.

Session I – General Session: (Chair F Reitsma)

The meeting chairman welcomed everyone to the second part of the 4th PBMR400 workshop. Reitsma gave a short overview of the current interest in HTRs and the need and motivation for the benchmark exercise.

The agenda was approved without any changes (see Annex I, Part II). The participants were given an opportunity to introduce themselves with a short description of the field in which they are working and their interest in the benchmark or HTRs in general.

Feedback was then provided on the updates made and progress since the 3rd workshop. The specification was finalised in June 2007 and placed on the Benchmark web site. It includes all agreed actions from the 3rd workshop (see NEA/NSC/DOC(2007)11 for details) including a kernel temperature approximate model for use during fast reactivity transients. The questionnaires to be completed were also made available in June 2007.

The next presentation gave a summary of the special session on the OECD PBMR 400MW benchmark planned for the PHYSOR 2008 meeting in Interlaken, Switzerland to be held from 14-19 September 2008. In total ten abstracts were submitted to the special session but the final number of papers accepted will only be known later in the year.

During this session, informal feedback was also provided by the OECD/NEA on the efforts made and status of the preservation of information and experiments in the area of HTRs. The archive on the DRAGON experience already consists of more than 1000 reports and the scanning and organization of documents are continuing. The value added by including experiments in the Reactor Physics and Criticality Handbooks was explained and includes, amongst many others, the quantification of experimental uncertainties, the provision of a best estimate reference model and details on material impurities. Specific efforts on HTR-10 (already included), the ASTRA facility (and plans to do heat-up experiments in 2009) and PROTEUS (water ingress and control rod movement) was mentioned.

Session II: Feedback by all participants I (Chair: K Ivanov)

The session was the first of two sessions where participants gave feedback on the work they performed related to the benchmark exercises.

In the presentation from Penn State University, made by Kostadin Ivanov, the development of MCNP models, based on the OECD benchmark specification, was described. The models make use of the given isotopic distribution of the fuel regions but generate its cross section libraries. Two models were investigated, the first with only five radial fuel materials (averaged over the axial height) and the second with the 110 fuel materials as defined. In both cases cross-sections were prepared defining 70 of the 72 isotopes (Np-240 and U-239 not available on basic library used) and assuming 1000K. The k-eff and radial profiles of the total flux, fission and absorption rates of the two models were compared with the relative errors provided (see presentation for details).

Brian Boer from TU Delft presented the status of the DALTON-THERMIX(Direkt) work performed at TU Delft. Results for the steady-state exercises and transient exercises 1, 2, 3 and 6 are available. A manual time step size was used for the coupling of the neutronic (DALTON, diffusion, finite volume) and thermal-hydraulic (THERMIX-DIREKT) codes and was chosen manually depending on the particular case so that convergence was obtained. Convergence for a time step is not checked and rather, small time steps are taken. The approximation needed, the results and discussion of the DLOFC, PLOFC and sensitivity of the re-criticality time in the case with no SCRAM were presented. Finally the exercise 6 results for the cold helium inlet scenario were discussed. Future improvements may include a more general time stepping procedure and additional validation with the historical AVR experiments.

From Nesca, South Africa, Rian Prinsloo presented updated results with the OSCAR-4 code system, and further work related to the benchmark. The presentation included an overview of the code system and work performed at Nesca. Although the official contribution is restricted to the steady-state exercise 1, related work includes cylindrical nodal code development, model comparisons in cooperation with PSU and activities in cross section parameterization methodologies based on an automated quasi-regression based parameterization.

An update of the TINTE results and related activities was given by Gerhard Strydom. A summary of the code features and mesh refinements in the models was described, and results for the transient cases were provided. The effect of the additional pressure built up in Case 3 (PLOFC) due to temperature increase was quantified and show a difference of 32 °C on the maximum temperature at ~ 40 hours into the transient. The differences between the newly implemented DIN standard and the TINTE approximate decay heat model was also quantified to be only 14 °C. Other important sensitivities shown include the cusping effect seen in exercise 5a with different blackness factors applied (to reduce the modelling error) as well as two specific sensitivity studies of interest on the UO₂ temperature (kernel specific model) and Doppler feedback effect. The newly implemented explicit kernel thermal hydraulic model was compared to the approximate method as proposed in the benchmark definition and the sensitivity of the temperatures and power excursion to the variation in the kernel material conductivity and specific heat values was investigated. In both cases the transient exercise 5b, which will show the largest sensitivity to the changes, was selected. The approximate PUEBH model as included in the benchmark specification shows very good agreement with the explicit model. This illustrates that the results obtained in the benchmark should be reasonable compared to better fuel temperature feedback models. Significant sensitivities to the thermal properties of the UO₂ kernel and its coatings were also shown, emphasizing the importance of these parameters.

The PARCS-3DTH solutions prepared by the University of Purdue were presented on their behalf by Kostadin Ivanov. The neutronic solver is mostly unchanged but a new 2D/3D porous media thermal hydraulic method was added including the most important phenomena such as a fuel temperature correction in fast reactivity transients and porous media dispersion effects in the azimuthal directions. No natural convection is currently available. Results for the transient cases using the updated code system were presented.

Session III. Feedback by all participants II (Chair: Rian Prinsloo)

Details on the MARS-GCR / CAPP model and transient results were presented by Seung Wook Lee and included details on the implemented heat conduction and transfer models, coolant flow definitions, heterogeneous pebble models and pebble bed correlations. The explicit coupling methodology was also explained. Results for the starting steady-state and several transient cases were represented. The results show good agreement with the expected transient behaviour and were confirmed with preliminary comparisons with TINTE.

Further developments of the CAPP code (Core Analyzer for Pebble and Prism) for VHTR's were presented by Hyun Chul Lee of KAERI. The FDM and FEM solutions methods are available in the code. Details of the 2D and different 3D finite elements were shared and described, as well as the linear equation solvers available. The OECD benchmark was used in the verification of the methods and compared with FD solutions for different order of shape functions and increase of the number of finite elements. Good agreement with a reference case and good convergence behaviour were illustrated.

Andreas Pautz, from GRS, presented the transient studies performed jointly with PSU with the coupled neutron transport / thermal hydraulics code system DORT-TD / THERMIX. The availability of a transport solution of the benchmark adds an important alternative to the otherwise all diffusion suite of codes although it should be kept in mind that the cross section library used is restrictive in representing true transport effects. The background and objectives of the tool's development were described with the features explained in some detail. Results for the steady state exercise 3 for the diffusion and transport options, with and without buckling feedback, were presented. The buckling feedback effect was quantified to be 1300 pcm and the transport effects around 650 pcm. The flux and power profiles were also compared and the transport solution yielded slightly higher power peaks. The fast control rod ejection (Case 5b) shows good agreement for the maximum power reached between transport and diffusion although a time shift was noticed, which was smaller than the impact of the correct modelling of fuel feedback temperatures (Doppler) and thermal conduction properties.

The DORT-TD's capabilities were further illustrated by the multi-group (beyond 2 groups) application utilizing higher scattering / quadrature order cross section data. The OECD PBMR400 and an earlier PBMR268 design were used. Cross-sections in 6-groups were generated independently making use of the MICROX-2 code. For the PBMR268 the k-eff variation for diffusion was smaller at 120 pcm and transients also showed much better agreement. P₁S₄ appears to be sufficient and the consistently generated cross-sections probably add to the good agreement.

In the presentation from PBMR the multi-dimensional cross section table approach used in this benchmark was compared to other representations available in TINTE and the new multi-group version of TINTE called MGT. The standard polynomial representation in TINTE, the tables in MGT but without the cross terms as in the benchmark and the new in-line spectrum calculation option in MGT, were introduced. Preliminary results were discussed but the explanation for large differences still needs to be investigated.

Gerhard Strydom presented the work of Hikaru Hiruta and co-authors from INL on their updated steady-state results. The status of the PEBBED coupled code and the transient code CYNOD was also given.

Session IV. Benchmark Steady State Cases (Chair: G Strydom)

The comparisons were prepared by PSU. A summary of the cases was presented in each case and then all the results were compared and discussed in the session. For detailed comments, please refer to the presentations in the proceedings. Only a few remarks will be made here.

In exercise 1 updated results were received from 11 participants mostly after further refinement of meshes or introduction of the correct void treatment. The spread in the k-eff values has improved compared to the previously reported values, especially if only the updated results are considered, but it is still larger than expected in this case as the cross section data are provided and differences should be limited. Participants should revisit their results and ensure that the mesh is fully refined (this was shown to increase the k-eff in most cases). It was noted that the VSOP k-eff = 1.0 result in the initial generation of

the cross-sections increased to 1.00455 with mesh refinement in CITATION. Power and flux profiles all show similar shapes and trends but larger differences in the 2-D shapes needs further attention and indicate differences in the effect of void modelling. The outlier results could in most cases be attributed to not updated earlier submissions.

Also the exercise 2 thermal hydraulics results still show some variations in temperatures. The definition of fuel, moderator, and maximum fuel temperature was clarified in previous meetings and included in the specification and should not be the reason for the differences. The following variations were identified as needing further investigations. Although the radially averages axial pebble surface temperatures compares well some differences in the radial profile suggest differences in the helium flow or heat transfer to the coolant in the different radial meshes. Differences in the moderator and fuel temperatures, also noticeable in the axial profiles, suggest differences in the thermal conductivity and or heat capacity of the fuel spheres. Two groups of results, the first from Thermix-Direkt and derivatives and the second from the Thermix-Konvek family, are visible. Participants have to carefully consider the heat transfer mechanisms implemented in these codes to ensure consistency with the benchmark definition or to identify and report any differences.

Results for exercise 3 of the steady-state cases were compared and discussed in this session. The spread in the results had reduced considerably since the previous submissions but some differences are still too large and need more attention. For example, the two PEBBED k-eff results are significantly higher than the other results (this was later corrected after the meeting). The other 2-D profiles show good correspondence in general but the detailed maps do show variations close to the void and boundary condition regions that are to be expected. The feedback effects (due to the coupled neutronics-thermal-hydraulics) also tend to smear out some of the differences that were seen in the Case 2 temperature profiles. It was clear from the discussions that the use of the coupled case with full feedback is more challenging than the two separated cases but that the feedback effects also reduce certain effects.

It was decided in the session that only results confirmed to be converged and with the supporting model questionnaire will be included in the official comparisons. Participants will be given a final opportunity to update results before they are published (see Action list below).

Sessions V & VI: Transient Cases Comparisons (Chair: E Sartori, A Pautz and F Reitsma)

This topic was divided over two session but the activities and results are summarised together. The Pennsylvania State University prepared the comparisons between all the participant's contributions for all the Transient Exercises. The detail can be found in the presentations and in the comparison spreadsheets available on the website. Only two and, for some cases, three sets of results were available for comparison. Some general comments are included below.

In Case 1 significant differences in the maximum fuel temperature were seen. A more peaked radial power profile in DALTON is one possible explanation for the difference. An investigation into the decay heat treatment in TINTE (DIN standard) compared to the specification (based on the DIN standard total heat) was further suggested. In particular the decay heat relative power profile in TINTE will tend to be smoother over time while the benchmark definition assumes the same relative power profile before shutdown (from steady-state solution). Despite this the re-criticality times were similar which suggest that the total heat deposited and losses should be similar. Case 2 and 3 show similar results related to decay heat sources and initial conditions.

The reactivity transient cases (5a and b) show fair agreement in many power and temperature shapes throughout the transients. The radial power profile shows similar differences as for the Steady-State 3 case with the MARS-GCR/CAPP more peaked towards the central reflector than the TINTE results. This could also be the reasons for the higher maximum fuel temperatures. Although the power excursion shows the same general behaviour the end state power level differs by ~60MW (on 730MW) for Case 5a. For Case 5b the large differences in the power excursion can be attributed to the absence of a kernel model (or correction) that calculate the correct fuel temperature and thus the correct feedback effects.

In Case 6 the radial temperature and power density differences (also from the starting steady-state conditions) also introduce differences throughout the transient while the axial profiles compare better. The increase in the power level after the transient was completed with the associated increase in the average and maximum fuel temperature in TINTE is not consistent with the other two results and needs to be investigated.

The final judgment on the transient case results could not be made on the limited set available at the meeting. More results should be made available (in total a minimum of 6 and a maximum of 8 sets of results could be expected for most transient cases) and better comparisons and conclusion can then be drawn.

Sessions VII & VIII. Discussion and closing (Chair: F. Reitsma)

During the closing session an action list was drafted (available as a link in the Agenda). The last benchmark meeting is planned to coinciding with PHYSOR2008 (this was confirmed). The chairman thanked all the participants and the meeting was adjourned.

Proceedings of the Workshop

Along with this summary participants will receive a CD-ROM containing all papers discussed at the meetings. The CD-ROM will also include all reports from previous workshops, which discuss this benchmark.

Task list / Outstanding issues – PBMR4 meeting

- PBMR4 meeting summary with all presentations to be published (also CD) Target 29 February 2008 (Actual May/June 2008)
 - Official summary, All presentations, All submitted spreadsheets, (updated comparison presentations if possible)
 - Action list with these deadlines and plans
- Discussions between current submissions to clarify differences (26 January – end March 2008; Actual: On-going)
 - TU Delft, PBMR, KAERI on transients (Action G Strydom)
 - Differences in Fission Power (Case 6)
 - Kernel model vs no kernel model
 - Differences between temperatures although powers are similar
 - Steady State submissions / updates / converged results (Action F Reitsma)
 - Plans of all participants
 - Old results updated or removed (as applicable)
- All outstanding code descriptions to be submitted by end of March 2008 (Actual: Ongoing, deadline 30 June)
- All updated results at PSU by 30 April 2008 (Only updated results for Steady State Cases (with refined mesh) and Transient Cases (since the definition was updated) will be accepted and compared. (all submissions prior to June 2007 will potentially be disregarded) (Actual: All updates received till 10 May for Steady State cases included in PHYSOR paper, Further updates deadline 30 June)
- All outstanding questionnaires to be submitted by 30 April 2008 (Actual: Ongoing)
- Updated comparison spreadsheets available end of May / mid June 2008 (Actual: Available results discussed with Prof. Ivanov till 27 May, Updates possible till 30 June 2008)
 - Will workshop these at PBMR in May with Prof Ivanov (Status: Done)
 - (additional questions may be sent to participants to try and understand / quantify differences)
 - Updated spreadsheets placed on web
- Finalised comparative spreadsheet and statistical analysis (PSU, end June 2008, Actual: mid July 2008)
- Draft Benchmark report sent to participants (mid August 2008)
 - Comments submitted by end August 2008
- Draft / Updated Report available at meeting at PHYSOR2008
 - Meeting on Sunday 14 September 2008 (TBC)
 - Last meeting to finalise the benchmark
- Final report at OECD end November 2008 / end January 2009
- Published report, March / April 2009
 - Presentations and other data on CD (cleaned version to get rid of inconsistencies)
- Special Journal issue to be published in 2009

The latest action list with target dates is provided in the table below:

Summary of Actions and Target Dates (Revised from the dates at the meeting)

1	Updates and final submission of: <ul style="list-style-type: none"> • Code descriptions • Questionnaires • Updates of any results 	30 June 2008
2	Updated comparison spreadsheets available to all	15 July 2008
3	Drafted Benchmark Report Action PBMR/Reitsma	15 August 2008
4	Comments on Benchmark Report Action: All	30 August 2008
5	5 th OECD PBMR 400MW Benchmark meeting	Sunday 14 September 2008 (At PHYSOR 2008 meeting),
6	Final report at OECD Action PBMR/Reitsma	November 2008 / end January 2009
7	Published report	March / April 2009
8	Special Journal issue to be published in 2009 Action PSU / Ivanov	News at 5 th meeting on 14 September

* Note that the above contains revised target dates (not the same as the draft in January) The CD distribution is planned for mid-June 2007.

Annex I

OECD/NEA/NSC
PBMR COUPLED NEUTRONICS/THERMAL HYDRAULICS TRANSIENT BENCHMARK
THE PBMR-400 CORE DESIGN– 4th Workshop

21 – 25 January 2008

FINAL PROGRAMME [P401]
([n] indicates paper identification on CD-ROM)

PART I: DIREKT Workshop

Day 1: 21 January 2008

- I. Theoretical Overview of DIREKT [D01]
- II. Input Description and Model Definition [D02]
- III. Code Layout [D03] and Installation

Day 2: 22 January 2008

- IV. Preparation of Steady State Calculations [Example D04]
- V. PBMR400 Steady State Case (Stationary run) [Example D05]

Day 3: 23 January 2008

- VI. Preparation and execution of a fast depressurization transient [Example D06]
- VII. Discussion on use and coupling with other codes

PART II: OECD PBMR400 Meeting

Day 4: 24 January 2008

- I. General Session (Chair: F. Reitsma)
 1. 09:15 – 09:30 Introduction and opening remarks – introduction of participants [P402]
 2. 09:30 – 09:35 Adoption of agenda
 3. 09:35 – 10:20
 - 3a Feedback on Benchmark Specification updates and PBMRT3.0 meeting [P403]
 - 3b Feedback on special session planned for PHYSOR2008 [P404]

10:20 – 10:45 Break

II. Feedback by all participants I (Chair: K Ivanov)

4. 10:45 – 12:45 Presentations from all participants on progress and results.

- 4a Ramatsemela Mphahlele, Dundar Ucar, Kostadin Ivanov, "PBMR-400 Neutronics Model using MCNP5" [P405]
 - 4b B. Boer, D. Lathouwers, J.L. Kloosterman, "DALTON-THERMIX calculation results for the transient benchmark cases" [P406]
 - 4c Rian Prinsloo, K Sekhri, "Investigation into steady state result discrepancies" [P407]
 - 4d Gerhard Strydom, "TINTE OECD PBMR 400MW Benchmark Results" [P408]
 - 4e V.Seker T Downar "PARCS-3DTH Solutions of the PBMR-400 Benchmark Transients" Presented by K Ivanov [P409]
- Discussions

12:45 – 14:00 Lunch

III. Feedback by all participants II (Chair: R Prinsloo)

5. 14:00 – 16:00 Presentations from all participants on progress and results.

- 5a Seung Wook Lee "MARS-GCR/CAPP Coupled Calculation for the OECD/NEA PBMR-400 Transient Benchmark Problems" [P410]
 - 5b Hyun Chul Lee, "Development of CAPP code: Comparison of the FDM and the FEM solutions to the OECD/NEA PBMR-400 benchmark problem Ex I-1" [P411]
 - 5c Andreas Pautz, "Transient Studies with the Coupled Neutron Transport / Thermal Hydraulics Code System DORT-TD / THERMIX" [P412]
 - 5d Ivor Clifford, F Reitsma, G Strydom "Cross Section Representation options for HTR Transient Analysis tested on the OECD PBMR 400MW Transient Benchmark" [P413]
 - 5e Hikaru Hiruta , Abderrafi M. Ougouag, Hans D. Gougar "Summary and Discussion of Results of Steady State and Transient Analyses by INL" Presented by Gerhard Strydom [P414]
- Discussions

16:00 – 16:20 Break

IV. Benchmark Steady State Cases (Chair: G Strydom)

6. 16:20 – 17:30 Steady State Test case 1 & 2 (K Ivanov / F Reitsma)

- 6a J. Han, P. Mkabela, K. Ivanov, F. Reitsma, "Comparison of Steady State Results of OECD PBMR-400 Benchmark" [P415]
- 6b Discussion

Day 5: 25 January 2008

V. Transient Cases Comparisons (Chair: E Sartori)

7. 09:00 – 12:30 Transient cases results and comparisons (K Ivanov / F Reitsma)

7a J. Han, P. Mkabela, K. Ivanov, F. Reitsma, "Comparison of Transient Results of OECD PBMR-400 Benchmark" [P416]

7b Discussion

10:20 – 10:45 Break

VI. Transient Cases Comparisons - Continue (Chair: Andreas Pautz)

12:30 – 13:45 Lunch

VII. Transient cases Discussions and Conclusions (Chair: F Reitsma)

8. 13:45 – 14:30 Transient Cases Discussions and Conclusions (K Ivanov / F Reitsma)

8a Discussion and summary

14:30 – 15:00 Break

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

9. 15:00 – 16:00 Discussion of future actions [P417], Special session at PHYSOR2008 and schedule

10. 16:00 – 16:15 Discussion of next meeting and missing deliverables

11. 16:15 – 16:30 Any other business and closure of meeting

Annex II

List of Participants

FRANCE:

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UNITED STATES OF AMERICA:

IVANOV, Kostadin, Head of RDFMG, Pennsylvania State University

INTERNATIONAL ORGANIZATIONS:

SARTORI, Enrico, OECD/NEA Databank