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

**OECD/NRC Boiling Water Reactor Turbine Trip Benchmark - Third Workshop (BWR-TT3) and  
Starter Meeting for the VVER-1000 Coolant Transient Benchmark (V1000-CT)**

**Rosendorf (Dresden), Germany  
28th to 30th May 2002**

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**OECD/NRC Boiling Water Reactor  
Turbine Trip Benchmark –Third Workshop  
(BWR-TT3)**

and

**Starter Meeting for the  
VVER-1000 Coolant Transient Benchmark  
(V1000-CT)**

Rosendorf (Dresden), Germany  
28<sup>th</sup> to 30<sup>th</sup> May 2002

Hosted by  
Forschungszentrum Rosendorf (FZR), Germany

**SUMMARY**

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**OECD/NRC Boiling Water Reactor  
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**and Starter Meeting for the  
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(V1000-CT)**

Rossendorf (Dresden), Germany, 28<sup>th</sup> - 30<sup>th</sup> May 2002

**Background and Purpose of the Benchmark Workshop**

The third workshop for the BWR TT Benchmark was held from the 28<sup>th</sup> through the 29<sup>th</sup> May 2002 in Rossendorf (Dresden), Germany. The workshop was hosted and sponsored by the Forschungszentrum Rossendorf (FZR) and the Section "Reactor Physics and Computational Methods" of the German Society of Nuclear Engineering (KTG). The BWR TT Benchmark is sponsored by the US Nuclear Regulatory Commission, the OECD, and Nuclear Engineering Program (NEP) at the Pennsylvania State University. Exelon Nuclear and EPRI, USA, assist in the analysis of the benchmark

The incorporation of full three-dimensional (3D) models of the reactor core into system transient codes allows for a "best-estimate" calculation of interactions between the core behavior and plant dynamics. Recent progress in computer technology has made development of coupled thermal-hydraulic (T-H) and neutron kinetics code systems feasible. Considerable efforts have been made in various countries and organizations in this direction. To verify the capability of the coupled codes to analyze complex transients with coupled core-plant interactions and to fully test thermal-hydraulic coupling, appropriate benchmarks need to be developed. The Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) is completing under the US Nuclear Regulatory Commission (NRC) sponsorship a PWR Main Steam Line (MSLB) Benchmark against coupled T-H and neutron kinetics codes. A small benchmark team from the Pennsylvania State University (PSU) has been responsible for developing the benchmark specification, assisting the participants and coordinating the benchmark activities. The benchmark was very well internationally accepted. It was felt among the participants that there should be a similar benchmark against the codes for a BWR plant transient. The Turbine Trip (TT) transients in a BWR are pressurization events in which the coupling between core phenomena and system dynamics plays an important role. In addition the available real plant experimental data makes the proposed benchmark problem very valuable. NEA, OECD and US NRC have approved it for the purpose of validating advanced system best-estimate analysis codes.

Three-turbine trip (TT) transients at different power levels were performed at the Peach Bottom (PB)-2 BWR/4 Nuclear Power Plant (NPP) prior to shutdown for refueling at the end of Cycle 2 in April 1977. The second test was selected for the benchmark problem to investigate the effect of the pressurization transient (following the sudden closure of the turbine stop valve) on the neutron flux in the reactor core. In a best-estimate manner the test conditions approached the design basis conditions as closely as possible. The actual data were collected, including a compilation of reactor design and operating data for Cycles 1 and 2 of PB and the plant transient experimental data. The transient was selected for this benchmark study, because it is a dynamically complex event for which neutron kinetics in the core was coupled with thermal-hydraulics in the reactor primary system.

The purpose of this third workshop was to present and discuss the results from Phase I, II and III of the benchmark, to share experience in analyzing BWR TT transients and to provide conclusions and recommendations based on the work carried out.

The last day was devoted to start the new benchmark, approved by the NSC/NEA OECD, concerned with the VVER-1000 Coolant Transient Benchmark (V1000-CT), based on experimental measurements. The benchmark defines a standard problem for validation of coupled three-dimensional (3-D) neutron kinetics/thermal-hydraulics system codes for application to Soviet-designed VVER-1000 reactors based on actual plant data. The overall objective is to assess the best estimate computer codes used in the safety analysis of VVER power plants, specifically for their use in reactivity transients in a VVER-1000. The benchmark is sponsored by the United States Department of Energy (US DOE), NEA/OECD, and NEP at PSU. The NEP, PSU, performs these international benchmark activities in collaboration and with assistance of the Argonne National Laboratory (ANL), USA.

The reference problem chosen for simulation in a VVER-1000 is a main coolant pump (MCP) switching on when the other three main coolant pumps are in operation. It is an experiment that was conducted by Bulgarian and Russian engineers during the plant-commissioning phase at the Kozloduy NPP Unit No. 6 as a part of the start-up tests. The test was done, as it is important for the safety of the NPP with VVER-1000, 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 29.45% of nominal power level according to the equipment that controls neutron flux. The control rod group No. 10 is inserted into the core at about 36% of the reactor core height. Analysis of the initial 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 ¼ of the core when MCP No. 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.

### **Session 1: Introduction**

The meeting was opened by Dr. Ulrich Grundmann from Safety Research, Forschungszentrum Rossendorf (FZR), as the Chairman of the Organising and Programme Committee of the Workshop. He chaired the Introductory Session 1. The director of the Institute of Safety Research, FZR, Prof. Frank Peter Weiss, welcomed the participants on the behalf of the FZR and gave an overview of the nuclear research performed at FZR. The workshop was attended by 38 participants representing 20 organisations from 9 countries. The actual number of participants having submitted results and presentations for the Third Workshop was larger than the number of attendees. The list of participants is provided in Annex 1. Some participants (denoted by stars) had to cancel their trip but they submitted presentations. The agenda, provided as Annex 2, was reviewed and adopted after minor changes.

Prof. Francesco D'Auria, on behalf of NEA, OECD, summarized the on-going and planned activities in the area of transient benchmarks. Tony Ulses, from US NRC, presented the status of the coupled TRAC-M/PARCS code development, including the methods development, experimental programs, and development assessment, and paying special attention to the BWR model improvements and modifications made in the code for BWR analysis.

## Session 2: BWRTT Phase I

Andy Olson from Exelon chaired Session 2 on the Phase 1 of the Benchmark. In her presentation Monica Vela Garcia from PSU presented a summary of the submitted participants' results for the first exercise in the form of tables and graphs. Fourteen results (fourteen organizations from eight countries) were submitted for the First Exercise calculated with eight different system codes. The comparative analysis was made for code-to-data and code-to-code comparisons using the standard statistical methodology and the ACAP automatic assessment tool. Further the participants presented their models, the obtained results and performed sensitivity studies for the first exercise (papers [b06] through [b11], see Annex 2).

In the following discussion of the results for Exercise 1, several issues were addressed:

- (a) The observed scattering in the void fraction distribution predictions – this can be attributed to the different methods used by the participants' codes for two-phase void distribution calculations, the separator modeling and different core nodalization schemes used in the participants' models.
- (b) The observed scattering in the pressure response – this affects the predicted core responses, and can be attributed to both codes' and user's capabilities.

The following suggestions were made and accepted to improve the quality of final report on the Phase 1:

- (a) The results of each organization have to be represented in a distinct way in the graphical comparisons. In order to have better comparisons, the plots have to be divided into two groups (because of the large number of submitted results).
- (b) For the comparisons of time histories it is better to compare the delta-changes vs. time instead actual values. For the comparison of the predicted sequences of events, some clarifications need to be made, such as the measured value of the time of bypass valve opening.
- (c) A questionnaire on the modelling options for use by participants will be prepared by the benchmark team and sent to participants. Each participant has to answer this questionnaire in a timely manner. In addition the participants will be asked to submit a one-to-two page description of their codes specifying exactly how they want the name of the code and the name of organization represented to appear in the final report.

## Session 3: BWRTT Phase II

Tony Ulses from US NRC chaired Session 3 on Phase 2 of the Benchmark. Monica Vela Garcia from PSU presented the summary of participants' results submitted for the Second Exercise in a form of tables and graphs. Fourteen participants from nine countries submitted their results. The performed comparative analysis indicated that while there is an improved agreement among the participants' predictions as compared to the preliminary comparisons presented at the 2<sup>nd</sup> Workshop there are still some issues to be resolved in order to improve the comparison of results. The participants' normalized power distributions (1-D Axial and 2-D Radial) for the transient snapshots should be re-normalized before being compared, taking into account the different power levels predicted by the participants. In addition, the relative axial power distribution at the two selected assembly positions should be compared in different clusters depending on the number of channels used in the participants' models and the use of assembly discontinuity factors (ADFs). Another source of disagreement was found in the fact that some of participants submitted their results based on total power and some on fission power. This effect is

especially strong for the snapshots after the scram where the decay heat modelling plays an important role. Further, the participants in their presentations discussed their models and coupling schemes, their results and sensitivity studies (see papers [b13] through [b19] in Annex 2). These studies included the pressure drop effects in the core support plate, the bypass channel modeling and bypass density correction, void correlations, etc.

In the following discussion several issues were addressed. First it was suggested that the deviations in the core average axial void fraction distribution at the initial steady state are caused mostly by the different void correlations, used in the participants' codes, and the sub-cooled boiling modeling. Some of the participants suggested to compare the core average void fraction and others the core fluid mass. Further, the importance of correct prediction of the core pressure drop was emphasized. The spatial distribution of the decay heat should follow the fission power distribution at the initial steady state.

The following suggestions were made and accepted to improve the quality of the final report on the Phase 2:

- The power comparisons will be made in two clusters – one based on total power, another on fission power. No comparisons of power distribution will be made for the end of transient (EOT) snapshot.
- A questionnaire on the modelling options for use by participants will be prepared by the benchmark team and sent to participants. Each participant has to answer this questionnaire in a timely manner. In addition the participants will be asked to submit a one-to-two page description of their codes with specifying exactly how they want the name of the code and the name of organization represented to appear in the final report.
- For this transient there is no evidence of boiling in the bypass. The sub-cooled effect is much stronger and it is recommended that the bypass density correction be modelled. In this regard it is important how the heat transfer between channel and bypass is modelled in addition to the direct heating modelling. These models have to be described in the answers to the questionnaire.

#### **Session 4: BWRTT Phase III**

Dr. Akitoshi Hotta of TEPSYS chaired Session 4 on Phase 3 of the benchmark. Monica Vela Garcia from PSU presented summary tables and graphs of submitted results. Seven participants from five countries have submitted their preliminary results for Exercise 3. Several issues, which could improve the comparisons, were identified. The relative axial power distributions at the selected assembly positions should be renormalized. Comparisons should be made only for the snapshot of the maximum power before the scram. Normalization of the LPRM should be unique for each participant. Andy Olson from Exelon presented results of sensitivity studies on steam separator inertia modelling. Higher inertia at the separator inlet causes higher mass flow rate in the core. Pressure oscillations are higher for this case and pressure response is delayed (pressure waves reach the core later). Lower inertia at the separator inlet causes lower mass flow rate in the core. Pressure oscillations are lower for this case. Further, the participants presented their models, the obtained results for both best-estimate and extreme scenarios, and the performed sensitivity studies (see papers [b22] through [b32] in Annex 2). Such sensitivity studies included TSV mass flow characteristics, carry-under and carry-over modelling, approximations in the cross-section history dependence modelling, temporal coupling and coupled convergence schemes, direct moderator heating modelling, bypass density correction modelling, and SRV modelling for the extreme scenarios.

In the following discussion, some suggestions were made and accepted for the Phase 3 simulations:

- Since the SRV modelling is very important for the extreme scenarios of Exercise 3, it needs to be clarified. TEPSYS and NFI in collaboration with the benchmark team will develop a concept for SRV modelling and distribute it among the participants
- It was suggested that for the LPRM normalization all the results be self normalized to 1 (in order to make the comparisons easier and to eliminate the differences caused by steady-state solution)
- The maximum cladding wall temperature should also be reported
- The mass balance of core should be also compared – the benchmark team will evaluate it from the solutions provided
- For pressure and mass flow rate comparisons of the time histories delta changes are to be compared not the absolute values
- Additional parameters are requested to be provided for comparison such as core exit flow, the time-dependent radial power peaking factor
- Snapshots are defined at time 0, the peak before scram, for every peak after the scram (for extreme scenarios) and at 5 seconds into the transient.

### **Session 5: Defining Work Plan and Schedule for BWRTT**

Dr. Siegfried Langenbuch from GRS chaired Session 5 on the future work plan and schedule of benchmark activities. The discussion was focused on the deadlines for submission of results and organization of future Workshops as well as actions required to finalize the reports of the three phases. The summary of the 3<sup>rd</sup> Workshop will be published as an NEA/NSC document and distributed to participants, together with other material of the Workshop, such as electronic copies of the presentations, etc., on a CD-ROM.

The deadline for submitting results for Exercises 1 and 2 is July 31, 2002. The deadline for submitting results for Exercise 3 is August 31, 2002. The Fourth BWR TT Benchmark Workshop will be held on October 6, 2002 (from 1 p.m. to 6 p.m.) in Seoul, Korea, in conjunction with PHYSOR 2002 conference. A special session will also take place at this conference on Numerical and Computational issues of Coupled 3-D Kinetics/Thermal-Hydraulic System Code Simulations: OECD/NRC BWR TT Benchmark.

After collecting the participants' final results for the three exercises the benchmark team will prepare three reports. Four reviewers were selected for each report as follows:

- For Final report on Exercise 1 (Volume 2): S. Langenbuch, F. D'Auria, W. Barten, and T. Ulses
- For Final report on Exercise 2 (Volume 3): U. Grundmann, A. Hotta, G. Verdu, and T. Ulses
- For Final report on Exercise 3 (Volume 4): E. Royer, R. Velten, A. Hotta, and T. Ulses

Finally, Prof. F. D’Auria presented information about the research activities under the EC CRISSUE-S Project and outlined the cooperation links between the OECD/NRC BWR TT benchmark activities as well as the future OECD/DOE VVER-1000 transient benchmark activities with the CRISSUE-S project. He proposed that the University of Pisa hosts the last OECD/NRC BWR TT Benchmark Workshop at the end of February 2003 in Pisa, Italy, in conjunction with the scheduled CRISSUE-S project meeting.

### **Session 6: VVER-1000 Coolant Transient Benchmark (V1000-CT)**

Session 6 was devoted to the Starter Meeting for the VVER-1000 Coolant Transient Benchmark (V1000-CT). First of all the participants introduced themselves and the organizations which they represented. Twenty-five participants representing seventeen organizations from eleven countries attended this Starter Meeting (see Annex 3).

Session 6 was divided in two parts. P. Siltanen from Fortum Nuclear Services Ltd. chaired the first part. In four presentations B. Ivanov and K. Ivanov from PSU (papers v03 through v06, Annex 2) summarized the information included in the Draft of VVER-1000 Benchmark Specifications: thermal-hydraulic plant data, neutronics core data, benchmark cross-section library, benchmark exercises and scenarios, and the requested output. For this benchmark there is available plant experimental data, collected during the conducted start-up test at the Kozloduy NPP, Unit 6, involving switching on of one main coolant pump (MCP) while the other three pumps were working. B. Ivanov also presented the RELAP5/MOD3 results for the 1<sup>st</sup> Exercise of the proposed VVER-1000 Benchmark, obtained by INRNE, Bulgaria (paper v07 of Annex 2). During the following discussion several modelling issues were addressed:

- Modelling of the expansion of fuel and cladding;
- Gas gap conductance modelling;
- Geometrical interpretation of the mass flow rate core inlet boundary conditions, calculated with TRAC-PF1/NEM for the 2<sup>nd</sup> exercise;
- Correct Xenon modelling for the initial steady state conditions for the MCP switching on transient test.

Dr. U. Rohde from the Institute for Safety Research, FZR, chaired the second part in which feedback from the potential participants in the V1000-CT Benchmark was presented. First, P. Siltanen presented the Atomic Energy Research (AER) working group “D” activities in developing and conducting VVER transient benchmarks. He then summarized the review of the draft of V1000-CT Benchmark Specifications conducted by the AER Working Group “D” at their meeting in Moscow, Russia, May 21-23, 2002 (papers [v08] and [v09], Annex 2). From the AER members the following organizations have expressed their intention to participate in the V1000-CT Benchmark: FZR, VTT, REZ, and INRNE. AEKI and VUJE will decide later while in KI there are different opinions among the various research groups (since the benchmark team has received confirmation from two groups of KI that they will participate in the benchmark). The most important critique expressed by the AER members was that the changes in power and temperatures during the switching on of one MCP transient are small and the transient might be not very interesting for spatial kinetics validation. The mixing of coolant before the core was found to be a more interesting feature. K. Ivanov answered this critique by pointing out that the proposed transient involves non-symmetrical power and feedback parameters distributions (even though they are not very strong) and the available test data can be used to validate the coupled codes while the proposed extreme scenario is designed to test fully the 3-D models. Further P. Siltanen presented in detail the AER technical comments on the Draft of the Specifications. K. Ivanov from PSU thanked the AER members for their

review and stated that all of their comments will be accounted for in the final version of the V1000-CT Benchmark Specifications.

Dr. W. Herring from FZK presented their experience in the neutronics design and safety investigations with relevance to VVER reactors (paper [v10], Annex 2). E. Royer from CEA presented the CEA/INRNE proposal to extend the V1000-CT benchmark with a MSLB phase (papers [v11a and v11b], Annex 2). The proposal was also sent to the participants prior the meeting and it is attached in Annex 4. Plant measured data from the coolant mixing experiments at low power will be used to test the vessel thermal-hydraulics on both levels – CFD calculations (which will be a parallel separate exercise) and macroscopic mixing models. The licensing Kozloduy NPP, unit 6 MSLB scenario will be utilized. K. Ivanov supported the proposal and underlined that the combined V1000-CT&MSLB benchmark is a much more comprehensive test and will broaden the international participation. He suggested that PSU, CEA-Saclay and INRNE form a joint benchmark team, which will finalize the Benchmark Specifications, coordinate benchmark activities and prepare the final reports under the NEA/OECD, US DOE and CEA sponsorship. Eric Royer also proposed, on behalf of CEA that the first V1000-CT&MSLB benchmark workshop be hosted by CEA and take place in Saclay. The participants accepted the proposal.

Dr. Yaroslav Kozmenkov from IPPE, Obninsk presented their experience in reactivity accident analysis using the coupled code DYN3D/RELAP5(paper [v12]).

### **Actions and Schedule for V1000-CT**

The following discussion of the schedule of planned V1000-CT&MSLB benchmark activities led to some conclusions, which the participants accepted:

- PSU, CEA, INRNE and KNPP will form a joint benchmark team to conduct the V1000-CT&MSLB benchmark under the NEA/OECD, US DOE and CEA sponsorship.
- The first V1000-CT&MSLB benchmark workshop will take place in June 2003 in Saclay and will be hosted by CEA. This workshop will be combined with the topical meeting of the AER Working Group “D”.
- The Final Benchmark Specifications will be prepared by the end of 2002 by a joint team of PSU and CEA, taking into account all the comments and additions presented at the meeting.

The NEA secretariat expressed appreciation to the host organization, FZR, and its staff, for their generous hospitality and outstanding efforts in making the 3<sup>rd</sup> OECD/NRC BWR TT Benchmark Workshop and the Starter Meeting on the V1000-CT&MSLB Benchmark a success.

Participants were taken on a guided tour of the ROCOM: Rossendorf Coolant Mixing Test Facility after the closing of the Workshop.

### **Proceedings of the Workshop**

Participants will receive a CD-ROM with this summary and all papers discussed at the meetings. The CD-ROM includes also all reports from previous workshops discussing this benchmark.

## Annex 1

## 3rd Workshop on the BWRTT Benchmark, Rossendorf, 28-30.5.2002

## List of Participants

**FINLAND**

DAAVITILA, Antti  
 Research Scientist  
 VTT Processes, Tekniikantie 4C, Espoo  
 P.O. Box 1604  
 FIN-02044 VTT

Tel: +358 9 456 5028  
 Fax: +358 9 456 5000  
 Eml: Antti.Daavittila@vtt.fi

**FRANCE**

MIGNOT, Gerard  
 DER/SERI/LCSI - Bat 212  
 CEA - CADARACHE  
 13108 St Paul Lez Durance

Tel: +33 4 4225 3354  
 Fax: +33 4 4225 3635  
 Eml: gerard.mignot@cea.fr

RAMEAU, Brigitte  
 CEA Grenoble  
 DEN/DTP/SMTH/LMDS  
 17 rue des Martyrs  
 38054 Grenoble Cedex 9

Tel: +33 04 38 78 59 95  
 Fax: +33 04 38 78 94 53  
 Eml: brigitte.rameau@cea.fr

ROYER, Eric  
 Centre d'Etudes de Saclay  
 CEA/DEN/DM2S/SFME  
 91191 Gif-sur-Yvette Cedex

Tel: +33 1 69 08 54 69  
 Fax: +33 1 69 08 85 68  
 Eml: eric.royer@cea.fr

**GERMANY**

GRUNDMANN, Ulrich  
 Institute of Safety Research  
 Forschungszentrum Rossendorf  
 Postfach 510119  
 D-01314 DRESDEN

Tel: +49 (351) 260 3037  
 Fax: +49 (351) 260 2383  
 Eml: U.Grundmann@fz-rossendorf.de

HERING, Wolfgang  
 Forschungszentrum Karlsruhe FZK  
 Institut für Reaktorsicherheit IRS  
 Herrmann-von-Helmholtz-Platz 1  
 Eggenstein-Leopoldshafen 76344

Tel: +49 (0) 7247 822556  
 Fax: +49 (0) 7247 823718  
 Eml: hering@irs.fzk.de

KARRASCH, Bernhard  
 Framatome ANP GmbH  
 NGES1  
 Bunsenstr. 43  
 Postfach 3220  
 D-91050 ERLANGEN

Tel: +49 9131 18 94011  
 Fax: +49 9131 18 94345  
 Eml: Bernhard.Karrasch@framatome-anp.de

KLIEM, Soeren  
 Forschungszentrum Rossendorf  
 Institute for Safety Research  
 P.O. Box 510119  
 D-01314 DRESDEN

Tel: +49 (351) 260 2318  
 Fax: +49 (351) 260 2383  
 Eml: kliem@fz-rossendorf.de

KRUESSENBERG, Anne  
 Institute of Safety Research  
 Forschungszentrum Rossendorf  
 Postfach 510119  
 D-01314 DRESDEN

Tel: +49 351 260 3067  
 Fax: +49 351 260 2021  
 Eml: a.kruessenberg@fz-rossendorf.de

LANGENBUCH, Siegfried  
Gesellschaft fuer Anlagen und  
Reaktorsicherheit mbH  
Postfach 13 28  
Forschungsgelaende  
D-85748 GARCHING

Tel: +49 (89) 3200 4424  
Fax: +49 (89) 3200 4599  
Eml: lab@grs.de

RINDELHARDT, Udo  
Institute of Safety Research  
Forschungszentrum Rossendorf  
Postfach 510119  
D-01314 DRESDEN

Tel: +49 (351) 260 3663  
Fax:  
Eml: u.rindelhardt@fz-rossendorf.de

ROHDE, Ulrich  
Forschungszentrum Rossendorf  
P.O.Box 51 01 19  
D-01314 Dresden

Tel: +49 351 260 3460  
Fax: +49 351 260 2383  
Eml: U.Rohde@fz-rossendorf.de

SCHMIDT, Klaus Dieter  
Gesellschaft fuer Anlagen und  
Reaktorsicherheit  
GRS mbH  
Forschungsgelaende  
D-85748 Garching

Tel: +49 89 3200 4425  
Fax: +49 89 3200 4599  
Eml: smk@grs.de

VELKOV, Kiril  
Gesellschaft fuer Anlagen und  
Reaktorsicherheit  
GRS mbH  
Forschungsgelaende  
D-85748 Garching

Tel: +49 (89) 3200 4428  
Fax: +49 (89) 3200 49038  
Eml: vek@grs.de

VELTEN, Roger  
Framatome-ANP GmbH  
Postfach 3220  
D-91050 ERLANGEN  
Freyeslebenstrasse 1

Tel: +49 (9131) 189 7564  
Fax: +49 (9131) 189 5243  
Eml: Roger.Velten@framatome-anp.de

WEISS, Frank-Peter  
Director  
Institute for Safety Research  
Research Center Rossendorf  
P.O. Box 51 01 19  
D-01314 DRESDEN

Tel: +49 (351) 260 3480  
Fax: +49 (351) 260 3440  
Eml: F.P.Weiss@fz-rossendorf.de

#### ITALY

BOUSBIA SALAH, Anis  
Universita degli Studi di Pisa  
Dept. of mechanical, nuclear  
& production engineering  
Via Diotisalvi, 2  
I-56126 PISA

Tel: +39 050 836675  
Fax: +39 050 836665  
Eml: o105808@docenti.ing.unipi.it

D'AURIA, Francesco  
Universita degli Studi di Pisa  
Dept. of mechanical, nuclear  
& production engineering  
Via Diotisalvi, 2  
I-56126 PISA

Tel: +39 (050) 836653  
Fax: +39 (050) 836665  
Eml: dauria@ing.unipi.it

## NEA/NSC/DOC(2002)11

LO NIGRO, Angelo  
Universita di Pisa  
Dept. of mechanical, nuclear &  
production engineering  
Via Leopardi 23-2  
16011 Arenzano (ge)

Tel: +39 010 5723883  
Fax: +39 010 9127643  
Eml: angelo.lonigro@rina.org

### JAPAN

HOTTA, Akitoshi  
TEPCO Systems Corporation  
In-Core Management Systems Dept.  
Tokyo Bijyutsu Club Building  
6-19-15 Shinbashi, Minato-ku  
TOKYO 105-0004

Tel: +81 (3) 4586 6742  
Fax: +81 (3) 4586 1190  
Eml: hotta-akitoshi@tepsys.co.jp

MIYAJI, Takamasa  
Nuclear Fuel Industries, Ltd.  
3135-41, Muramatsu,  
Tokai-mura Naka-gun,  
Ibaraki, 319-1196

Tel: +81 29 287 8236  
Fax: +81 29 287 8222  
Eml: Miyaji@nfi.co.jp

UI, Atsushi  
Nuclear Fuel Industries, Ltd.  
3135-41, Muramatsu,  
Tokai-mura Naka-gun,  
Ibaraki, 319-1196

Tel: +81 29 287 8236  
Fax: +81 29 287 8222  
Eml: ui@nfi.co.jp

UTSUNO, Hideaki  
Institute of Nuclear Safety (INS)  
Nuclear Power Engineering Corporation (NU  
Fujita Kanko - Toranomom Bldg. 7F  
3-17-1, Toranomom, Minato-ku  
TOKYO 105-0001

Tel: +81 3 4512 2742  
Fax: +81 3 4512 2799  
Eml: utsuno@nupec.or.jp

### RUSSIAN FEDERATION

\* DANILIN, Sergey  
RRC "Kurchatov Institute"  
Institute of Nuclear Reactors  
VVER Department  
Kurchatov sq. 1  
123182 Moscow

Tel: +7 (095) 196 7750  
Fax: +7 (095) 196 6172  
Eml: serg@vver.kiae.ru

KOZMENKOV, Yaroslav  
Institute of Physics and Power Eng.  
Bondarenko Sq.1  
Obninsk, 249 033, Kaluga Region

Tel:  
Fax: +7 +49 351 260 2383  
Eml: Y.Kozmenkov@fz-rossendorf.de

### SPAIN

\* ARAGONES BELTRAN, Jose M.  
Dept. de Ingenieria Nuclear  
ETSI-Industriales  
Univ. Politecnica de Madrid  
Jose Gutierrez Abascal 2  
E-28006 MADRID

Tel: +34 91 336 3108  
Fax: +34 91 336 3002  
Eml: arago@din.upm.es

GOMEZ, Andres J.  
Iberdrola Ingenieria  
y Consultoria  
Ave. Burgos 8B  
E-28036 MADRID

Tel: +34 91 767 52 34  
Fax: +34 91 767 53 89  
Eml: agn@iberdrolaingenieria.es

VERDU MARTIN, Gumersindo  
 Departamento de Ingenieria Quimica y Nucl  
 Universidad Politecnica  
 Campus Camino de Vera  
 P.O. Box 22012  
 46071 VALENCIA

Tel: +34 96 387 76 30  
 Fax: +34 96 387 76 39  
 Eml: gverdu@iqn.upv.es

**SWEDEN**

PANAYOTOV, Dobromir  
 Westinghouse  
 SE-721 63 Vasteras

Tel: +46 21 347743  
 Fax: +46 21 348 299  
 Eml: dobromir.panayotov@se.westinghouse.com

**SWITZERLAND**

BARTEN, Werner  
 Laboratory for Reactor Physics  
 and Systems Behaviour  
 Paul Scherrer Institut  
 CH-5232 Villigen PSI

Tel: +41 56 310 41 16  
 Fax: +41 56 310 23 27  
 Eml: Werner.Barten@psi.ch

FERROUKHI, Hakim  
 Nuclear Energy and Safety Research Depart  
 Laboratory for Reactor Physics and System  
 Behaviour  
 Paul Scherrer Institut  
 CH-5232 Villigen PSI

Tel: +41 (0)56 310 4062  
 Fax: +41 (0)56 310 2327  
 Eml: Hakim.Ferroukhi@psi.ch

**UNITED STATES OF AMERICA**

IVANOV, Boyan  
 Nuclear Engineering Programme  
 The Pennsylvania State University  
 16 Reber Building  
 University Park PA 16802-1408

Tel: +1 (814) 865 8751  
 Fax: +1 (814) 865 8499  
 Eml: bivanov@psu.edu

IVANOV, Kostadin  
 Associate Professor  
 Nuclear Engineering Programme  
 The Pennsylvania State University  
 230 Reber Building  
 University Park PA 16802

Tel: +1 (814) 865 0040  
 Fax: +1 (814) 865 8499  
 Eml: knil@psu.edu

OLSON, Andy  
 Exelon Corporation  
 200 Exelon Way, KSA-2N  
 Kennett Square  
 PA 19348

Tel: +1 (610) 765 5830  
 Fax: +1 (610) 765 5651  
 Eml: andy.olson@exeloncorp.com

SARIKAYA, Baris  
 Nuclear Engineering Programme  
 The Pennsylvania State University  
 16 Reber Building  
 University Park PA 16802

Tel: +1 (814) 865 8751  
 Fax: +1 (814) 865 8499  
 Eml: sarikaya@psu.edu

ULSES, Tony P.  
 Office of Research  
 USNRC  
 MS T 10K8  
 Washington, DC 20555

Tel: +1 301 415 6002  
 Fax: +1 301 415 5160  
 Eml: apu@nrc.gov

VELA GARCIA, Monica  
Nuclear Engineering Programme  
The Pennsylvania State University  
230 Reber Building  
University Park PA 16802

Tel: +1 814 865 8751  
Fax: +1 814 863 4848  
Eml: mxv185@psu.edu

**International Organisations**

SARTORI, Enrico  
OECD/NEA Data Bank  
Le Seine-Saint Germain  
12 boulevard des Iles  
F-92130 ISSY-LES-MOULINEAUX

Tel: +33 1 45 24 10 72 / 78  
Fax: +33 1 45 24 11 10 / 28  
Eml: sartori@nea.fr

\* regrets not to have been able to attend

## Annex 2

### Workshop Programme

( [nn] indicates the paper number as identified on CD-ROM)

#### **Session 1** Chair: Ulrich Grundmann

- Introduction and Welcome
  - Intorduction of Participants [b01]
  - Review of Agenda [b02]
- Frank-Peter Weiss: Activities at FZR [b03]
- Opening remarks on behalf of NEA - Francesco D’Auria
- Tony P. Ulses: “Status of TRACM/PARCS Development,” [b04]

#### **Session 2** Chair: Andy Olson

##### ***Phase I***

1. Monica Vela-Garcia: First Exercise – Presentation of Summary Tables & Graphs of Results Submitted [b05]
2. Presentation of results by participants
  - Tony Ulses and Bedirhan Akdeniz,, “OECD/NRC Boiling Water Reactor Turbine Trip Benchmark, TRAC-M Analysis for Exercise 1”[b06]
  - D. Panayotov: OECD BWR TT Benchmark Exercise 1: Final Results obtained with POLCA-T code [b07]
  - W. Barten, H. Ferroukhi, P. Coddington: OECD/NEA & USNRC BWR Turbine Trip Benchmark: PSI Final Results of Phase I and Parameter Variation using RETRAN-3D [b08]
  - Atsushi Ui, Takamasa Miyaji: “Peach Bottom 2 Turbine Trip Benchmark using TRAC-BF1/COS3D, Exercise I” [b09]
  - Bedirhan Akdeniz, and Barish Sarikaya: "OECD/NRC Boiling Water Reactor Turbine Trip Benchmark, TRAC-BF1 Analysis for Exercise 1" [b10]
  - B. Karrasch,: Exercise 1 : S-RELAP5 Results [b11]
3. Discussion of Results

#### **Session 3** Chair: Anthony Ulses

##### ***Phase II***

1. Monica Vela- Garcia: Second Exercise - Presentation of Summary Tables & Graphs of Results Submitted [b12]
2. Presentation of results by participants
  - S.Langenbuch,K.-D.Schmidt,K.Velkov: Sensitivity study for BWR-TT benchmark, Phase 2, by the coupled code ATHLET-QUABOX/CUBBOX [b13]
  - Ulrich Grundmann, Ulrich Rohde: “DYN3D - Results for Phase 2 of the BWR TT Benchmark by Using Different Models” [b14]
  - Baris Sarikaya and Kostadin Ivanov: Analysis of the BWR Turbine Trip Core Transient with TRAC-BF1/NEM (Exercise 2) [b15]

- Takamasa Miyaji, Atsushi Ui: "Peach Bottom 2 Turbine Trip Benchmark using TRAC-BF1/COS3D, Exercise II [b16]
  - W. Barten, H. Ferroukhi, P. Coddington: OECD/NEA & USNRC BWR Turbine Trip Benchmark: PSI Results of Phase II with Flow and Pressure Boundary Conditions using RETRAN-3D [b17]
  - A. Salah, J. Vedovi, F. D'Auria, G. Galassi, and K. Ivanov: "Results for Exercise 2 Using Coupled RELAP5/PARCS Codes" [b18]
  - B. Karrasch, R. Velten: Exercise 2 : Results based on RAMONA5 Calculations [b19]
3. Discussion of Results

**Session 4** Chair: Akitoshi Hotta

**Phase III**

1. Bedirhan Akdeniz and Monica Vela-Garcia: Exercise 3 – Presentation of Summary Tables & Graphs of Results Submitted [b20]
2. Andy Olson: Steam Separator Inertia Sensitivity Studies for Exercise 3 [b21]
3. Presentation of results by participants
  - B. Karrasch, R. Velten: Exercise 3: S-RELAP5 / RAMONA5 (3d) Control Rod Insertion at 0.75 sec : Preliminary Results [b22]
  - Anis Bousbiah Salah: Preliminary Results of Exercise 3 using Coupled RELAP5/PARCS codes [b23]
  - Akitoshi Hotta: Results of Exercise 3 by TRAC/BF1-ENTRÉE [b24]
  - Eric Royer, Gerard Mignot: CEA preliminary results for exercise 3 [b25]
  - S.Langensbuch,K.-D.Schmidt,K.Velkov: Preliminary results for BWR-TT benchmark, Phase3, by the coupled code ATHLET-QUABOX/CUBBOX[b26]
  - D. Panayotov: OECD BWR TT Benchmark Exercise 3: Preliminary Results obtained with POLCA-T code [b27]
  - Tony P. Ulses, Deokjung Lee, Thomas Downar: "Peach Bottom 2 turbine Trip Benchmark Exercise 3 Analysis [b28]
  - Atsushi Ui, Takamasa Miyaji: "Peach Bottom 2 Turbine Trip Benchmark using TRAC-BF1/COS3D, Exercise III" [b29]
  - W. Barten, H. Ferroukhi, P. Coddington: OECD/NEA & USNRC BWR Turbine Trip Benchmark: PSI First Results of Phase III using RETRAN-3D [b30]
  - G. Verdú: Sensitivity Analysis of the Results of the Third Exercise
  - T. Ulses, and B. Akdeniz: "PARCS/TRAC-M Analysis - Exercise 3 Extreme Scenarios Modelling" [b32]
4. Discussion of Results

**Session 5** Chair: Siegfried Langensbuch

1. Defining work plan and schedule, actions required for finalising the reports of the 3 phases
  - Actions for 4<sup>th</sup> Workshop, 6 October 2002 at Seoul
  - Schedule of Publication
  - Session at Physor-2002: Status of Papers and publishing in journals
2. F. D'Auria: Information about and Co-operation with the EC CRISSUE-S Project

**Session 6**

*Part 1* Chair: P. Siltanen

***VVER-1000 Coolant Transient Benchmark. (V1000-CT)***

Introduction of participants [v01]

1. Presentation of Draft Benchmark Specification:
  - B. Ivanov and K. Ivanov : “VVER-1000 Thermal-hydraulic plant data” [v03]
  - B. Ivanov and K. Ivanov, “Neutron kinetics core specifications for VVER-1000 Benchmark” [v04]
  - B. Ivanov and K. Ivanov, “VVER-1000 Benchmark Cross-Section Library – Cross-Section Generation and Modeling” [v05]
  - B. Ivanov, and K. Ivanov “VVER-1000 Benchmark – Exercises (Phases) and Scenarios” [v06]
  - P. Groudev, and M. Pavlova: “RELAP5/MOD3.3 Investigation of Exercise 1 of the VVER-1000 Benchmark” [v07]

*Part 2* Chair: U. Rohde

***Feedback from discussions at the Atomic Energy Research (AER) meeting in Moscow concerning AER participation / sponsorship***

1. P. Siltanen : Review of V1000-CT Specification by AER Working Group D. [v08]
2. P. Siltanen: AER Working Group D: Overview of AER Dynamic Benchmarks in 3D Hexagonal Geometry [v09]
3. Comments from participants
  - V. Sanchez, C. Broeders, W. Hering: FZK/IRS Experience in Neutronic design and Safety Investigations with Relevance to VVER-Reactors [v10]
  - D. Caruge, N. Kolev, E. Royer,: Extension of Benchmark with a phase on a VVER-1000 MSLB Benchmark Problem [v11a, v11b]
4. Participants’ presentation on their experience analyzing VVER-1000 reactivity transients
  - Y. Kozmenkov, Y. Orekhov, U. Grundmann, S. Kliem, S. Mittag, U. Rohde, Benchmarking of the DYN3D/RELAP5 Code System [v12]
5. Work plan and schedule

**Date and place of the first workshop for the V1000-CT1 benchmark**  
(proposed: CEA Saclay France)

**Conclusion and Closing Remarks****Visit of ROCOM Facility**

A visit the mixing facility ROCOM during the workshop was arranged for interested participants.

**Annex 3**

**VVER-1000 Coolant Transient Start Meeting, 30 May 2002 Rossendorf)**

**List of Participants**

**CZECH REPUBLIC**

HADEK, Jan  
Nuclear Research Institute Rez plc  
250 68 Rez near Prague

Tel: +420 2 6617 2169  
Fax: +420 2 6617 2334  
Eml: hdj@ujv.cz

**FINLAND**

DAAVITILA, Antti  
Research Scientist  
VTT Processes, Tekniikantie 4C, Espoo  
P.O. Box 1604  
FIN-02044 VTT

Tel: +358 9 456 5028  
Fax: +358 9 456 5000  
Eml: Antti.Daavittila@vtt.fi

SILTANEN, T. Pertti J.  
Fortum Nuclear Services Ltd.  
P.O. Box 10  
Rajtorpantie 8, Vantaa  
FIN-00048 FORTUM

Tel: +358 1045 32412  
Fax: +358 1045 33355  
Eml: Pertti.Siltanen@fortum.com

**FRANCE**

ROYER, Eric  
Centre d'Etudes de Saclay  
CEA/DEN/DM2S/SFME  
91191 Gif-sur-Yvette Cedex

Tel: +33 1 69 08 54 69  
Fax: +33 1 69 08 85 68  
Eml: eric.royer@cea.fr

**GERMANY**

GRUNDMANN, Ulrich  
Institute of Safety Research  
Forschungszentrum Rossendorf  
Postfach 510119  
D-01314 DRESDEN

Tel: +49 (351) 260 3037  
Fax: +49 (351) 260 2383  
Eml: U.Grundmann@fz-rossendorf.de

HERING, Wolfgang  
Forschungszentrum Karlsruhe FZK  
Institut für Reaktorsicherheit IRS  
Herrmann-von-Helmholtz-Platz 1  
Eggenstein-Leopoldshafen 76344

Tel: +49 (0) 7247 822556  
Fax: +49 (0) 7247 823718  
Eml: hering@irs.fzk.de

KLIEM, Soeren  
Forschungszentrum Rossendorf  
Institute for Safety Research  
P.O. Box 510119  
D-01314 DRESDEN

Tel: +49 (351) 260 2318  
Fax: +49 (351) 260 2383  
Eml: kliem@fz-rossendorf.de

LANGENBUCH, Siegfried  
Gesellschaft fuer Anlagen und  
Reaktorsicherheit mbH  
Postfach 13 28  
Forschungsgelaende  
D-85748 GARCHING

Tel: +49 (89) 3200 4424  
Fax: +49 (89) 3200 4599  
Eml: lab@grs.de

MITTAG, Siegfried  
Forschungszentrum Rossendorf  
Postfach 510119  
01314 DRESDEN

Tel: +49 351 260 2094  
Fax: +49 351 260 2383  
Eml: mittag@fz-rossendorf.de

RINDELHARDT, Udo  
Institute of Safety Research  
Forschungszentrum Rossendorf  
Postfach 510119  
D-01314 DRESDEN

Tel: +49 (351) 260 3663  
Fax:  
Eml: u.rindelhardt@fz-rossendorf.de

ROHDE, Ulrich  
Forschungszentrum Rossendorf  
P.O.Box 51 01 19  
D-01314 Dresden

Tel: +49 351 260 3460  
Fax: +49 351 260 2383  
Eml: U.Rohde@fz-rossendorf.de

SANCHEZ-ESPINOZA, Victor Hugo  
Institute of Reactor Safety (IRS)  
Forschungszentrum Karlsruhe GmbH  
Hermann-von-Helmholtz-Platz 1  
D-76344 Eggenstein-Leopoldshafen

Tel: +49 7247 82 2283  
Fax: +49 7247 82 3718  
Eml: sanchez@irs.fzk.de

SCHMIDT, Klaus Dieter  
Gesellschaft fuer Anlagen und  
Reaktorsicherheit  
GRS mbH  
Forschungsgelaende  
D-85748 Garching

Tel: +49 89 3200 4425  
Fax: +49 89 3200 4599  
Eml: smk@grs.de

VELKOV, Kiril  
Gesellschaft fuer Anlagen und  
Reaktorsicherheit  
GRS mbH  
Forschungsgelaende  
D-85748 Garching

Tel: +49 (89) 3200 4428  
Fax: +49 (89) 3200 49038  
Eml: vek@grs.de

WEISS, Frank-Peter  
Director  
Institute for Safety Research  
Research Center Rossendorf  
P.O. Box 51 01 19  
D-01314 DRESDEN

Tel: +49 (351) 260 3480  
Fax: +49 (351) 260 3440  
Eml: F.P.Weiss@fz-rossendorf.de

#### ITALY

BOUSBIA SALAH, Anis  
Universita degli Studi di Pisa  
Dept. of mechanical, nuclear  
& production engineering  
Via Diotisalvi, 2  
I-56126 PISA

Tel: +39 050 836675  
Fax: +39 050 836665  
Eml: o105808@docenti.ing.unipi.it

D'AURIA, Francesco  
Universita degli Studi di Pisa  
Dept. of mechanical, nuclear  
& production engineering  
Via Diotisalvi, 2  
I-56126 PISA

Tel: +39 (050) 836653  
Fax: +39 (050) 836665  
Eml: dauria@ing.unipi.it

LO NIGRO, Angelo  
Universita di Pisa  
Dept. of mechanical, nuclear &  
production engineering

Tel: +39 010 5723883  
Fax: +39 010 9127643  
Eml: angelo.lonigro@rina.org

NEA/NSC/DOC(2002)11

Via Leopardi 23-2  
16011 Arenzano (ge)

**JAPAN**

HOTTA, Akitoshi  
TEPCO Systems Corporation  
In-Core Management Systems Dept.  
Tokyo Bijyutsu Club Building  
6-19-15 Shinbashi, Minato-ku  
TOKYO 105-0004

Tel: +81 (3) 4586 6742  
Fax: +81 (3) 4586 1190  
Eml: hotta-akitoshi@tepsys.co.jp

**RUSSIAN FEDERATION**

\* DANILIN, Sergey  
RRC "Kurchatov Institute"  
Institute of Nuclear Reactors  
VVER Department  
Kurchatov sq. 1  
123182 Moscow

Tel: +7 (095) 196 7750  
Fax: +7 (095) 196 6172  
Eml: serg@vver.kiae.ru

KOZMENKOV, Yaroslav  
Institute of Physics and Power Engineerin  
Bondarenko Sq.1  
Obninsk  
249 033, Kaluga Region

Tel:  
Fax: +7 +49 351 260 2383  
Eml: Y.Kozmenkov@fz-rossendorf.de

**SPAIN**

\* ARAGONES BELTRAN, Jose M.  
Dept. de Ingenieria Nuclear  
ETSI-Industriales  
Univ. Politecnica de Madrid  
Jose Gutierrez Abascal 2  
E-28006 MADRID

Tel: +34 91 336 3108  
Fax: +34 91 336 3002  
Eml: arago@din.upm.es

**SWEDEN**

PANAYOTOV, Dobromir  
Westinghouse  
SE-721 63 Vasteras

Tel: +46 21 347743  
Fax: +46 21 348 299  
Eml: dobromir.panayotov@se.westinghouse.com

**SWITZERLAND**

FERROUKHI, Hakim  
Nuclear Energy and Safety Research Dep.  
Laboratory for Reactor Physics and System  
Behaviour  
Paul Scherrer Institut  
CH-5232 Villigen PSI

Tel: +41 (0)56 310 4062  
Fax: +41 (0)56 310 2327  
Eml: Hakim.Ferroukhi@psi.ch

**UNITED STATES OF AMERICA**

IVANOV, Boyan  
Nuclear Engineering Programme  
The Pennsylvania State University  
16 Reber Building  
University Park PA 16802-1408

Tel: +1 (814) 865 8751  
Fax: +1 (814) 865 8499  
Eml: bivanov@psu.edu

IVANOV, Kostadin  
Associate Professor  
Nuclear Engineering Programme  
The Pennsylvania State University  
230 Reber Building  
University Park PA 16802

Tel: +1 (814) 865 0040  
Fax: +1 (814) 865 8499  
Eml: knil@psu.edu

SARIKAYA, Baris  
Nuclear Engineering Programme  
The Pennsylvania State University  
16 Reber Building  
University Park PA 16802

Tel: +1 (814) 865 8751  
Fax: +1 (814) 865 8499  
Eml: sarikaya@psu.edu

**International Organisations**

SARTORI, Enrico  
OECD/NEA Data Bank  
Le Seine-Saint Germain  
12 boulevard des Iles  
F-92130 ISSY-LES-MOULINEAUX

Tel: +33 1 45 24 10 72 / 78  
Fax: +33 1 45 24 11 10 / 28  
Eml: sartori@nea.fr

**Annex 4**

**VVER-1000 MSLB BENCHMARK PROBLEM**

**Proposal by**

**N. Kolev (INRNE), D. Caruge, E. Royer (CEA/SFME)**

**Abstract**

Modern integrated codes incorporate 3D neutronics coupled to 3D core and 3D vessel thermal hydraulics. For comprehensive assessment of such codes, a set of coolant transients involving different flow regimes and core-plant interactions has to be calculated. The DOE/OECD proposed VVER-1000 coolant transient benchmark (V1000-CT) is one case of this set.

In order to analyse other relevant mixing patterns, CEA in cooperation with INRNE is preparing a VVER-1000 MSLB benchmark with special emphasis on testing 3D neutronics/3D vessel thermal hydraulics models. The reference plant is Kozloduy-6, as in the DOE/OECD proposed pump start-up problem, and the multi-level testing approach is adopted. The realistic scenario involves asymmetric overcooling, stuck rod(s) and faulted loop MCP coastdown. A modified MSLB scenario is also provided for better testing the predictions of coupled codes. Compared to the TMI-1 MSLB benchmark, there are two new features:

- Plant measured data from coolant mixing experiments at low power and CFD code calculations will be used in a separate exercise to test the vessel thermal hydraulics (coolant mixing models).
- An additional option for coupled N-vessel-coreTH with imposed vessel inlet and outlet boundary conditions will be specified.

The coolant mixing will be analysed using CFD codes of CEA such as TRIO-U and CAST3M. The MSLB benchmark problem will be analysed with CATHARE2 and the results will be compared to those obtained by integrated codes using 3D kinetics such as CATHARE-FLICA-CRONOS and others. CFD calculations will be provided for those who are interested in testing 3D vessel thermal hydraulic models.

## Annex 5

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

**Dr. Ulrich GRUNDMANN**      Tel: +49 (351) 260 3037  
**Chairman**      Fax: +49 (351) 260 2383  
 Institute of Safety Research      E-mail: [U.Grundmann@fz-rossendorf.de](mailto:U.Grundmann@fz-rossendorf.de)  
 Forschungszentrum Rossendorf  
 Postfach 510119  
 D-01314 DRESDEN, Germany

**Udo RINDELHARDT**      Tel: +49 (351) 260 3663  
**Local Organiser**      E-mail: [u.rindelhardt@fz-rossendorf.de](mailto:u.rindelhardt@fz-rossendorf.de)  
 Institute of Safety Research  
 Forschungszentrum Rossendorf  
 Postfach 510119  
 D-01314 DRESDEN, Germany

**Farouk ELTAWILA**      Tel: +1 (301) 415-5471  
 Safety Margins &      Fax: +1 (301) 415-5160  
 System Analysis Branch      Email: [fxe@nrc.gov](mailto:fxe@nrc.gov)  
 Office of Nuclear Regulatory Research  
 Nuclear Regulatory Commission  
 MSTW10E46, 11555 Rockville Pike  
 Rockville, MD 20852, USA

**Member of CSNI Working Groups, NEA, OECD**

**Jennifer UHLE**      Tel: +1 301 415 6023  
 Safety Margins &      Fax: +1 301 415 5160  
 System Analysis Branch      E-mail: [JXU1@nrc.gov](mailto:JXU1@nrc.gov)  
 Office of Nuclear Regulatory Research  
 Nuclear Regulatory Commission  
 MSTW10E46, 11555 Rockville Pike  
 Rockville, MD 20852, USA

Jose-Maria ARAGONES      Tel: +34 91 336 3108  
 Professor      Fax: +34 91 336 3002  
 Dept. de Ingenieria Nuclear      E-mail: [arago@din.upm.es](mailto:arago@din.upm.es)  
 ETSI-Industriales  
 Univ. Politecnica de Madrid  
 Jose Cutierrez Abascal 2  
 E-28006 Madrid, Spain  
**Member of NSC, NEA, OECD**

**Andreas M. OLSON**      Tel: +1 (610) 765-5861  
 Fuel & Services Division      Fax: +1 (610) 765-5651  
 PECO Nuclear      E-mail: [andy.olson@exeloncorp.com](mailto:andy.olson@exeloncorp.com)  
 200 Exelon Way, KSA2-N  
 Kennett Square, PA 19348, USA

**Kostadin N. IVANOV**  
Associate Professor  
Nuclear Engineering Program  
The Pennsylvania State University  
230 Reber Building  
University Park, PA 16802, USA

Tel: +1 (814) 865-0040  
Fax: +1 (814) 865-8499  
E-mail: [kni1@psu.edu](mailto:kni1@psu.edu)

**Secretariat:**

**Enrico SARTORI and Jacques ROYEN**  
OECD / Nuclear Energy Agency  
12 boulevard des Iles  
92130 Issy les Moulineaux, FRANCE  
+33 1 45 24 10 72 (Phone), +33 (1) 4524 1110 (Fax)  
+33 1 45 24 10 52 (Phone), +33 (1) 4524 1129 (Fax)  
Email: [sartori@nea.fr](mailto:sartori@nea.fr) and [jacques.royen@oecd.org](mailto:jacques.royen@oecd.org)