NUCLEAR SCIENCES COMMITTEE
and
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

OECD/DOE/CEA VVER-1000 Coolant Transient Benchmark - First Workshop (V1000-CT1)

12-13 May 2003
Saclay (Paris), France

Hosted by

Commissariat a l'Energie Atomique, Centre d'Etudes de Saclay, France

SUMMARY RECORD

Content:

Background and Purpose of the Benchmark Workshop

The first workshop for the VVER-1000 Coolant Transient Benchmark TT Benchmark was held on 12th and 13[Th] May 2003. The workshop was hosted by the Commissariat à l'Energie Atomique, Centre d'Etudes de Saclay, France. The VVER-1000 Coolant Transient (V1000CT) Benchmark is sponsored by the US Department of Energy (DOE), Commissariat a l'Energie Atomique (CEA), France, the OECD, and the Nuclear Engineering Program (NEP) of the Pennsylvania State University. The Kozloduy Nuclear Power Plant (KNPP) and the Institute for Nuclear Research and Nuclear Energy (INRNE), Bulgaria, assist in providing the data and analysis of the benchmark. There is also an active co-operation with AER Working Group D (WGD), whose experience for VVER reactors is very valuable.

The V1000CT benchmark defines standard problems for validation of coupled three-dimensional (3-D) neutron-kinetics/system thermal-hydraulics codes for application to Soviet-designed VVER-1000 reactors using actual plant data without any scaling. The overall objective is to access computer codes used in the safety analysis of VVER power plants, specifically for their use in reactivity transient simulations in a VVER-1000. The V1000CT benchmark consists of two phases: V1000CT-1 – simulation of the switching on of one main coolant pump (MCP) while the other three MCP are in operation, and V1000CT-2 – calculation of coolant mixing tests and Main Steam Line Break (MSLB) scenario. Further background

information on this benchmark can be found at the OECD/NEA benchmark web site http://www.nea.fr/html/science/transients/v1000ct.html

The purpose of the first workshop was to review the benchmark activities after the Starter Meeting held last year in Dresden, Germany: to discuss the participants' feedback and modifications introduced in the Benchmark Specifications on Phase 1; to present and to discuss modelling issues and preliminary results from the three exercises of Phase 1; to discuss the modelling issues of Exercise 1 of Phase 2; and to define work plan and schedule in order to complete the two phases

Session 1 – Introduction: *Chair D. Caruge*

The meeting was opened by Dr. Daniel Caruge, Head of Service at CEA, Saclay that was hosting the meeting. He welcomed the participants on behalf of CEA, Saclay, and wished them a successful meeting. Enrico Sartori welcomed participants on behalf of the OECD/NEA and thanked in particular the local organisers for their hospitality. Dr. Pavlin Groudev welcomed the participants on behalf of the international benchmark team.

The meeting was attended by 33 participants from 11 countries (see Annex I). The agenda was approved with minor adjustments (see Annex II). The list of codes used in the benchmark is given in Annex 3.

P. Groudev presented an overview of the Main Coolant Pump test. K. Ivanov reviewed the status of V1000CT-1 (Phase1) benchmark activities while E. Royer gave an overview of the V1000CT-2 benchmark activities.

Session 2: *Chair*: *J. Gehin*

K. Ivanov reviewed the received participants' comments and the modifications introduced in the V1000CT-1 benchmark specifications. P. Groudev presented the thermal-hydraulic data and modeling issues of Exercise 1 of V1000CT-1. These presentations were followed by a discussion, which identified the following issues to be clarified:

- The temperature measurements including the initial conditions for loop # 3

- The time delay in temperature measurements and how to incorporate it for comparison with calculated results

- The initial values of parameters important for the transient - pressure drop in the reactor pressure vessel (RPV); core power level; and water level in the steam-generator (SG) and how they are measured

- Pressurizer level regulation and logic: set points, and mass flow in make-up/let-down systems

- Pressure drop measurements (especially for MCP #3) and mass flow rates

- Secondary side boundary conditions (BC) for SGs

- The thickness of primary loop piping (wall thickness)

Session 3: *Chair: S. Kliem*

B. Ivanov presented the neutronics data and modelling issues of Exercise 2 of Phase 1 followed by the discussion of cross-section libraries for Phases 1 and 2. K. Ivanov reviewed the modelling issues of Exercise 3. In the discussion the following questions were raised:

- Distribution of the decay heat power during the transient

- Correct equilibrium Xenon distribution for the initial steady state

Session 4: *Chair: P. Groudev*

The participants presented their preliminary results for Phase 1 of the V1000CT-1 benchmark. CEA presented their comments and suggestions. The University of Pisa analysed Exercise 1 and hot zero power (HZP) state of Exercise 2 using RELAP5/PARCS. FZR presented their models and results with the coupled code DYN3D/ATHLET for Exercise 3 of the benchmark. FZK discussed their results for Exercise 1 obtained with RELAP-5. KU presented their RELAP-3D model and results for Exercise 3 including the extreme scenario. ORNL presented their models for VVER-1000 and the obtained results with RELAP5-3D for Exercise 1 of the VVER-1000 CT benchmark for Phase 1. ORNL also made an analysis in depth of the test data, modelling challenges for the simulated transient, and associated uncertainties. The following modelling issues were addressed and the following suggestions were made by the participants in their presentations:

- Pump reverse flow rate and reverse flow losses in the line

- Individual MCP flow vs. head characteristics (pump modelling)

- Primary pressure vs. the pressurizer level relation

- Introduction of additional extreme scenario for Exercise 3 with higher scram set point of 3120 MWt power level

- Sensitivity study on refinement of cross-section library (using more reference points)

- Spacer grids and lower plate – axial locations and pressure loss coefficients

- The weighting approach for moderator temperature coefficient (MTC) and Doppler temperature coefficient (DTC) calculations

- Definition of the snapshot at maximum power for the best estimate scenario of Phase 1

- Add local parameters (in the core) – axial power distributions in selected assemblies for initial steady state and selected snapshots - in the requested outputs for Exercises 2 and 3

- To compare time histories of radial and axial power peaking factors and axial offset

Session 5: *Chair: K. Ivanov*

P. Groudev reviewed reference results, measured data and uncertainty ranges for Phase 1. B. Ivanov discussed the changes in requested output while J. Vedovi presented an update on methodologies for comparative analysis of participants' results. The following issues were discussed:

- The uncertainty range for the new initial power level of 824 MWt

- Measurement of uncertainty ranges for the transient

- Results to be provided for 800 seconds for all of the code-to-code comparisons

- Core exit temperatures to be compared to the measured data

Session 6: *Chair: P. Siltanen*

This session was devoted to a discussion of preliminary V1000CT-2 Specifications. First, N. Kolev discussed the available additional data and its modelling. Second, E. Royer presented expected experience in CFD. In the follow-up discussion, the following recommendations were made for preparing the V1000CT-2 Specifications:

- Demonstrate that neutronics is not necessary for Exercise 1 of Phase 2

- Clarify how the power distribution is defined: neutronics measurement or deltaT measurement

- Demonstrate that the core inlet flow distribution does not affect the calculation (effect of cross flows)

- Investigate the flow patterns for conditions of temperature rise or drop

- Pessimistic scenario of MSLB will be computed first because there is no flow reversal

Session 7: *Chair A. Hotta*

The topic of the last session was the participants' experience on VVER analysis and vessel CFD modelling. L. Sabotinov presented applications of CATHARE code for VVER accident analysis; E. Royer presented applications of Trio_U/Priceles on mixing problems in RPV. S. Kliem made an overview in three consecutive presentations on possible further VVER-1000 experiments and their modelling, coupled code calculations of VVER reactors at FZR, and CFD calculations for the RPV of VVER-440. T. Kozlowski discussed the new HEX and cross-section functionality in PARCS. S. Nikonov made a very interesting presentation and demonstration of the simulation of 3-D distribution of coolant characteristics of the RPV by the coupled code ATHLET/BIPR&KN.

K. Ivanov reviewed the status of the new proposed BFBT Benchmark based on the NUPEC experimental data. This benchmark aims at substantially refining models for best estimate calculations based on good quality experimental data. The needs arising in this respect are not limited to currently available macroscopic approaches but are now extending to next-generation approaches that focus on more microscopic processes. It is suggested that this international benchmark be based on data made available from the NUPEC database. This high quality data would encourage advancement in the insufficiently developed field of the two-phase flow theory. Considering that the present theoretical approach is

relatively immature, the benchmark specification needs to be designed so that it would systematically assess and compare the participants' numerical models on the prediction of detailed void distributions and critical powers. The new proposal, in the form of a report describing scope, objective and expected impact, will be submitted to the June 2003 NSC meeting for endorsement.

K. Ivanov summarized the participants' comments and suggestions, provided at the Workshop, and pointed out that they are very helpful to define a unified modelling basis. The suggestions can be classified in four categories:

- Clarifying values of some parameters and provided SG BC

- Providing more information for modelling some system components

- Refining the use of the available measured data

- Performing additional sensitivity studies

E. Sartori initiated a discussion about the V1000CT benchmark schedule and the next workshop. As a result, the following V1000CT schedule and list of actions were accepted by the workshop participants:

- End-May 2003 – Draft of the Workshop Summary

- Mid-June 2003 – Final Workshop Summary

- End-June 2003 – Updated Electronic Version of the Specification

- End-August 2003 – V1000CT Benchmark Paper for the AER Symposium and Summary for PHYSOR 2004

- End-December 2003 – Draft of Specifications for Phase 2 (Exercise 1)

- Mid-February 2004 – Deadline for submitting Results for Exercises 1 and 2, Phase 1

- 5-8 April 2004 - Second V1000CT Benchmark workshop in conjunction with the AER WGD Meeting in Bulgaria

Proceedings of the Workshop

Participants will receive with these proceedings 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.

Co-operation with AER

The AER Working Group D meeting was held during 14-15 May 2003 at the same premises. The co-operation of this working group with the VVER-1000 benchmark group was endorsed by the OECD/NEA NSC and is supported by the Safety Division. The members of the AER WGD have confirmed their participation in the OECD/DOE/CEA V1000CT benchmark. The summary of this meeting has been prepared separately and is available to the AER participants.

Results of Discussion at the NSC meeting (June 2003) concerning the BFBT Benchmark

The proposal for the international benchmark based on NUPEC BWR Full Size Bundle Tests (BFBT) was presented. The importance of this benchmark was stressed by many members of the NSC and its organisation was endorsed.

In general, for the benchmark activities of best estimate 3D core/plant coupling methods, appreciation was expressed by the NSC members.

Annex 1

**OECD/DOE/CEA VVER-1000 Coolant Transient Benchmark
First Workshop (V1000-CT1)**

Saclay (Paris), France
12-13 May 2003

Hosted by
Commissariat à l'Energie Atomique, Centre d'Etudes de Saclay, France

AGENDA

May 12th

Session 1 – Session Chair – Daniel Caruge

09:00-09:30 Introduction and Welcome, Participation [01], Approval of Agenda [02], Codes used [03]
         CEA – *Daniel Caruge*
         INRNE/KNPP – *Pavlin Groudev*
         OECD-NEA – *Enrico Sartori*
09:30-10:00 P. Groudev, V. Hadjiev, M. Pavlova:
         Investigation of a VVER 1000 Main Coolant Pump Switching on Problem [04]
10:00-10:30 Overview and status of V1000CT-1 (Phase 1) benchmark - *Kostadin Ivanov [05]*
10:30-11:00 Overview and status of V1000CT-2 benchmark - *Nikola Kolev, Eric Royer [06]*

11:00-11:15 Coffee Break

Session 2 – Session Chair – Jess Gehin

11:15-11:45 Comments and Modifications of V1000CT-1 Specifications - *Kostadin Ivanov [07]*
11:45-12:45 Discussion of V1000CT-1 – Thermal-Hydraulics data and Modeling Issues of Exercise 1 –
         Pavlin Groudev [08]

12:45-14:00 Lunch

Session 3 – Session Chair – Soeren Kliem

14:00-14:30 Discussion of V1000CT-1 – Neutronics Data and Modeling Issues of Exercise 2 -
         Boyan Ivanov [09]
14:30-15:00 Cross-section libraries for Phase 1 and Phase 2 of the Benchmark - *Boyan Ivanov [10]*
15:00-15:30 Discussion of V1000CT-1 – Modelling Issues of Exercise 3 - *Kostadin Ivanov [11]*

15:30-15:45 Coffee Break

Session 4 – Session Chair – Pavlin Groudev

15:45-17:30 Participants experience
- *Juswald. Vedovi, Alessandro. Petruzzi, Kostadin Ivanov, Francesco D'Auria:: "Joint Preliminary Analysis of VVER-1000 Benchmark Performed by PSU and U-Pisa" [12]*
- *Yaroslav Kozmenkov: Modelling the V1000CT-1 Benchmark with the Coupled Code DYN3D/ATHLET [13]*
- *Victor Sánchez-Espinoza, O. Metz: Preliminary Results of RELAP5 for Exercise 1 [14]*
- *Alexander Shkarupa: VVER-1000 Kozloduy Benchmark RELAP5-3D Analysis. Preliminary Results [15]*
- *Emilian Popov, Graydon L. Yoder, V. Velichkov: "Modeling Main Coolant Pump Start-up with RELAP5-3D". [16]*
- *L. Sabotinov: Application of CATHARE computer code for VVER accident analysis [17]*

17:30-18:30 Reception

May 13th

Session 5 – Session Chair – Kostadin Ivanov

9:00-10:00   Discussion of V1000CT-1 - Reference results, measured Data and Uncertainty Ranges – *Pavlin Groudev [18]*
10:00-10:30 Discussion of V1000CT-1 - Changes in Requested output - *Boyan Ivanov [19]*
10:30-11:00 Update on Methodologies for comparative analysis of participants results [20] - *Juswald Vedovi*

11:00-11:15 Coffee Break

Session 6 – Session Chair – Pertti Siltanen

11:15-12:15 Discussion of preliminary V1000CT-2 Specifications –
Nikola Kolev, Yavor Dinkov, Georgi Kotev: Additional data and modeling – [21]
Nikola Kolev, Tsvetan Topalov, Dimitar Popov, Evgeni Lukanov; Experimental Data [22]
12:15-12:45 Discussion of preliminary V1000CT-2 Specifications – Expected experience in CFD – *Eric Royer [23]*

12:45-14:00 Lunch

Session 7 – Session Chair – Akitoshi Hotta

14:00-15:45 Participants experience on VVER analysis and vessel CFD modelling
- *Ulrich Bieder: Applications of Trio_U/PRICELES on mixing problems in the RPV [24]*
- *Soeren Kliem: Possible Further VVER-1000 Experiments and their Modelling [25]*
- *Soeren Kliem: Overview on Coupled Code Calculations for VVER Reactors [26]*
- *Thomas Hoehne, Soeren. Kliem: CFD Calculations for the RPV of a VVER-440 [27]*
- *Tomasz Kozlowski: "New HEX and cross-section functionality in PARCS"[28]*
- *Serguei P. Nikonov, A.V.Kotsarev, M.P.Lizorkin: 3D Distribution of Coolant Characteristics in the Reactor Pressure Vessel by Coupled Code ATHLET/BIPR8KN[29]*
- *Mie Azuma, Akitoshi Hotta: Strategy on VVER1000 CFD analysis expected by TEPSYS' [30]*
- *Luben Sabotinov: Application of CATHARE computer code for VVER accident analyses[31]*

15:45-16:00 Status of BFBT Benchmark – *Hideaki Utsuno (NUPEC) and Kostadin Ivanov (PSU) [32]*
OECD/NRC Benchmark Based on NUPEC BWR Full-size Fine-mesh Bundle Tests BFBT), January 2003 [33]

16:00-16:30 Discussion – Benchmark schedule, next workshops..… - *Enrico Sartori*

16:30-16:40 Conclusion and closing remarks

Annex 2

First Workshop on VVER-1000 Coolant Transients, Saclay 12-13 May 2003)

List of Participants

BULGARIA
```
  DINKOV, Yavor                       Tel:
  Kozloduy Nuclear Power Plant        Fax:
  3321 Kozloduy, Bulgaria             Eml: ydinkov@npp.cit.bg

  GRUDEV, Pavlin                      Tel: +359 2 71 44 585
  Institute for Nuclear Research      Fax: +359 2 975 3619
    and Nuclear Energy - BAS          Eml: pavlinpg@inrne.bas.bg
  Tsarigradsko shaussee 72
  1784 Sofia

  KOLEV, Nikola                       Tel: +359 2 7144502
  INRNE                               Fax: +359 2 9753619
  Institute of Nuclear Research       Eml: npkolev@inrne.bas.bg
    and Nuclear Energy
  Boul. Tsarigradsko chaussee 72
  1784 Sofia

  KOTEV, Georgi                       Tel:
  Kozloduy Nuclear Power Plant        Fax: +359 973 72762
  3321 Kozloduy, Bulgaria             Eml: gkotev@npp.cit.bg

  LUKANOV, Evgeni                     Tel:
  Kozloduy Nuclear Power Plant        Fax: +359 973 72762
  3321 Kozloduy, Bulgaria             Eml: lukanov_ep@npp.cit.bg

  POPOV, Dimitar                      Tel: +359 973 723 86
  Safety Analysis Section,            Fax: +359 973 72762
  Engineering Support Division        Eml: dmpopov@npp.cit.bg
  IO-2, EP-2
  3321 NPP KOZLODUY

 * TOPALOV, Tsvetan                   Tel:
  Kozloduy Nuclear Power Plant        Fax:
  3321 Kozloduy, Bulgaria             Eml: topalov@npp.cit.bg
```

CZECH REPUBLIC
```
  HADEK, Jan                          Tel: +420 2 6617 2169
  Nuclear Research Institute Rez plc  Fax: +420 2 6617 2334
  250 68 Rez near Prague              Eml: hdj@ujv.cz

  TINKOVA, Eva                        Tel: +420 2 41006 116
  Nuclear Research Institute, Rez,    Fax: +420 2 41006 109
  Division Energoprojekt              Eml: tinkova@egp.cz
  Vyskocilova 3 / 741,
  POB 158,
  140 21 Prague 4
```

FINLAND
```
  HAMALAINEN, Anitta                  Tel: +358 9 456 5023
  Senior Research Scientist           Fax: +358 9 456 5000
  VTT Processes                       Eml: anitta.hamalainen@vtt.fi
  Nuclear Energy
  P.O. Box 1604
  FIN-02044 VTT

  SILTANEN, T. Pertti J.              Tel: +358 1045 32412
  Fortum Nuclear Services Ltd.        Fax: +358 1045 33355
  P.O. Box 10                         Eml: Pertti.Siltanen@fortum.com
  Rajatorpantie 8, Vantaa
  FIN-00048 FORTUM
```

FRANCE

    BIEDER, Ulrich   Tel: +33 4 38 78 95 14
    CEA Grenoble   Fax:
    17 rue des Martyrs   Eml: ulrich.bieder@cea.fr
    38054 GRENOBLE

    BOURNEL-BOSSON, Christophe   Tel:
    Centre d'Etudes de Saclay   Fax:
    CEA/DEN/DM2S/SFME   Eml: bournel@soleil.serma.cea.fr
    91191 Gif-sur-Yvette Cedex

    CARUGE, Daniel   Tel: +33 1 69 08 21 61
    DRN/DMT/SERMA   Fax: +33 1 69 08 85 68
    Commissariat à l'Energie Atomique (CEA)   Eml: daniel.caruge@cea.fr
    Centre d'Etudes Nucléaires de Saclay
    F-91191 Gif-sur-Yvette CEDEX

    ROYER, Eric   Tel: +33 1 69 08 54 69
    Centre d'Etudes de Saclay   Fax: +33 1 69 08 85 68
    CEA/DEN/DM2S/SFME   Eml: eric.royer@cea.fr
    91191 Gif-sur-Yvette Cedex

    SABOTINOV, Luben   Tel: +33 1 58 35 71 59
    Institut de Radioprotection et de   Fax: +33 1 47 46 86 76
    Surete Nucleaire IRSN   Eml: luben.sabotinov@irsn.fr
    B.P. 17
    92262 Fontenay-aux-Roses Cedex

GERMANY

    KLIEM, Soeren   Tel: +49 (351) 260 2318
    Forschungszentrum Rossendorf   Fax: +49 (351) 260 2383
    Institute for Safety Research   Eml: kliem@fz-rossendorf.de
    P.O. Box 510119
    D-01314 DRESDEN

    KOZMENKOV, Yaroslav   Tel:
    FZ Rossendorf   Fax: +49 351 260 2383
    Institute of Safety Research   Eml: Y.Kozmenkov@fz-rossendorf.de
    P.O. Box 510119
    D-01314 DRESDEN

  * LANGENBUCH, Siegfried   Tel: +49 (89) 3200 4424
    Gesellschaft fuer Anlagen und   Fax: +49 (89) 3200 4599
      Reaktorsicherheit mbH   Eml: lab@grs.de
    Postfach 13 28
    Forschungsgelaende
    D-85748 GARCHING

    SANCHEZ-ESPINOZA, Victor Hugo   Tel: +49 7247 82 2283
    Institute of Reactor Safety (IRS)   Fax: +49 7247 82 3718
    Forschungszentrum Karlsruhe GmbH   Eml: sanchez@irs.fzk.de
    Hermann-von-Helmholtz-Platz 1
    D-76344 Eggenstein-Leopoldshafen

HUNGARY

    HEGYI, György   Tel:
    Reactor Analysis Department   Fax: +36 1 395 9293
    KFKI Atomic Energy Research Institute   Eml: ghegyi@sunserv.kfki.hu
    H-1525 BUDAPEST 114
    P.O. Box 49

    KERESZTURI, Andras   Tel: +36 1 392 2297
    Reactor Analysis Department   Fax: +36 1 395 9293
    KFKI Atomic Energy Research Institute   Eml: kere@sunserv.kfki.hu
    H-1525 BUDAPEST 114
    P.O. Box 49

ITALY

PETRUZZI, Alessandro
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: alexpetruzzi56@hotmail.com

JAPAN

 * ASAHI, Yoshiro
JAERI
Center for Neutron Science Research
TOKAI-Mura
Ibaraki-ken 319-1195

Tel: +81 (29) 282 6096
Fax: +81 (29) 282 6438
Eml: asahi@mike.tokai.jaeri.go.jp

AZUMA, Mie
In-Core Fuel Managment Dept.
TEPCO Systems Corporation
Tokyo Bijyutsu Club Building
6-19-15 Shinbashi, Minato-ku
TOKYO 105-0004

Tel: +81 3 4586 6745
Fax: +81 3 4586 1190
Eml: azuma-mie@tepsys.co.jp

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

NIKONOV, Sergey
Russian Research Center
Kurchatov Institute
Kurchatov Square 1
Moscow 123182

Tel: +7 095 196 76 83
Fax: +7 095 196 6172
Eml: niks@vver.kiae.ru

UKRAINE

SHKARUPA, Alexander
International Nuclear Safety Center
National University of Kyiv
Building 11
Glushkov avenue 2
KYIV 03022

Tel: +380 44 239 31 16
Fax: +380 44 266 92 16
Eml: shkarupa@i.kiev.ua

UNITED STATES OF AMERICA

 * DOWNAR, Thomas J.
School of Nuclear Engineering
Purdue University
1290 Nuclear Engineering Bldg
W. LAFAYETTE, IN 47907-1290

Tel: +1 (765) 494 5752
Fax: +1 (765) 494 9570
Eml: downar@ecn.purdue.edu

GEHIN, Jess C.
Oak Ridge National Laboratory
Building 6025, MS-6363
Bethel Valley Road
P.O.Box 2008
OAK-RIDGE, Tennessee 37831-6363

Tel: +1 865 576 5093
Fax: +1 865 574 9619
Eml: gehinjc@ornl.gov

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

Tel: +1 (814) 865 3926
Fax: +1 (814) 865 8499
Eml: bivanov@psu.edu

```
IVANOV, Kostadin                        Tel: +1 (814) 865 0040
Associate Professor                     Fax: +1 (814) 865 8499
Nuclear Engineering Programme           Eml: knil@psu.edu
The Pennsylvania State University
230 Reber Building
University Park PA 16802

KOZLOWSKI, Tomasz                       Tel: +1 (765) 494 5752
School of Nuclear Engineering           Fax: +1 (765) 494 9570
Purdue University                       Eml: tomasz@ecn.purdue.edu
1290 Nuclear Engineering Bldg
W. LAFAYETTE, IN 47907-1290

VEDOVI, Juswald                         Tel: +1 (814) 865-8751
Nuclear Engineering Program             Fax: +1 (814) 865-8499
Dpt. Mechanical & Nuclear Engineering   Eml: juvl@psu.edu
The Pennsylvania State University
231 Sackett Building
University Park PA 16802-1408

YODER, Graydon L.                       Tel: +1 (865) 574 5282
Thermal Hydraulics and                  Fax: +1 (865) 574 2032
      Irradiation Engineering Group     Eml: yodergljr@ornl.gov
PoBox 2009, MS 8045
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-8045
```

International Organisations
```
SARTORI, Enrico                         Tel: +33 1 45 24 10 72 / 78
OECD/NEA Data Bank                      Fax: +33 1 45 24 11 10 / 28
Le Seine-Saint Germain                  Eml: sartori@nea.fr
12 boulevard des Iles
F-92130 ISSY-LES-MOULINEAUX
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* regrets not to be able to attend

33 participants from 11 countries

Annex 3

List of Codes

Country / Participant	Establishment	Code(s) Used
BULGARIA		
DINKOV, Y.	KNPP	CATHARE 3D
GRUDEV, Pavlin	INRNE	RELAP5/MOD3.2
KOLEV, Nikola	INRNE	CATHARE 3D
KOTEV, Georgi	KNPP	CATHARE 3D
LUKANOV, E.	KNPP	CATHARE 3D
TOPALOV, Ts.	KNPP	CATHARE 3D
CZECH REPUBLIC		
HADEK, Jan	NRI REZ	RELAP5-3D or DYN3D/ATHLET
TINKOVA, E.	NRI REZ	
FINLAND		
HAMALAINEN, Anitta	VTT	HEXTRAN-SMABRE
SILTANEN, T. Pertti J.	FORTUM	
FRANCE		
BIEDER, Ulrich	CEAGRENOBLE	
BOURNEL-BOSSON, C.	CEASACLAY	
CARUGE, Daniel	CEASACLAY	
ROYER, Eric	CEASACLAY	
GERMANY		
KLIEM, Soeren	FZR	
KOZMENKOV, Yaroslav	IFZR	DYN3D/ATHLET
SANCHEZ-ESPINOZA, Victor Hugo	FZK	RELAP5/PARCS
HUNGARY		
HEGYI, György	KFKI	
KERESZTURI, Andras	KFKI	
ITALY		
PETRUZZI, Alessandro	UNIPISA	RELAP5/PARCS
JAPAN		
AZUMA, Mie	TEPCO	
HOTTA, Akitoshi	TEPCO	
ASAHI, Yoshiro	JAERI	THYDE-NEU
RUSSIAN FEDERATION		
DANILIN, Sergey	RRCKI	
NIKONOV, Seguey	IRRCKI	ATHLET/BIPR8KN
UKRAINE		
SHKARUPA, Alexander	INSC	

Country / Participant	Establishment	Code(s) Used
UNITED STATES OF AMERICA		
Downar, Tom J.	UPURDUE	
GEHIN, Jess C.	ORNL	RELAP5-3D
IVANOV, Boyan	PSU	TRAC-PF1/NEM
IVANOV, Kostadin	PSU	TRAC-PF1/NEM
KOZLOWSKI, Tomasz	UPURDUE	
VEDOVI, Juswald	PSU	
YODER, Graydon L.	ORNL	RELAP-3D
International Organisations		
SARTORI, Enrico	NEA	