ORGANISATION FOR ECONOMIC CO-OPRATION AND DEVELOPMENT

NUCLEAR ENERGY AGENCY

Nuclear Science Committee

and

Committee on the Safety of Nuclear Installations

Summary of the First Workshop on

OECD/NRC BOILING WATER REACTOR TURBINE TRIP BENCHMARK

9-10 November 2000
Philadelphia, USA

Hosted by
Exelon Nuclear

Introduction

The meeting was opened by Professor Kostadin Ivanov from the Nuclear Energy Program (NEP) of PSU, principal investigator of the OECD/NRC BWR TT benchmark project and a representative of the Organising Committee of the Workshop. In the Introductory Session, E. Sartori welcomed participants on behalf of the OECD/NEA and explained the role and the interest the OECD/NEA Nuclear Science Committee (NSC) and Committee on the Safety of Nuclear Installations (CSNI) have in the Workshop and in the benchmark study. He introduced the three speakers: Kevin Donovan, Director of Nuclear Fuel Management of Exelon Nuclear, host of the Workshop, Ashok Thadani, Director of Nuclear Regulatory Research of the US NRC, co-sponsor of the workshop and benchmark study, and José Maria Aragonés, professor at the Polytechnic University of Madrid and Member of the Nuclear Science Committee. He then passed on the floor to each.

Kevin Donovan explained that Exelon Corporation was established through a recent merger of Peco Energy and Commonwealth Edison and that they are now operating 17 reactors in the USA: in Pennsylvania, Illinois and New Jersey. They are operating the Peach Bottom-2 (PB2) Nuclear Power Plant (NPP), where the experiments involving the turbine trips were carried out and which form the basis of the benchmark study. They have an interest in best estimate and safety codes. For this they keep close contacts and collaborate with the NEP at PSU. Also international co-operation in this area is of interest to their organisation.

Ashok Thadani underlined the importance of realistic safety analysis as the starting point for new evolutions. In the US important changes are taking place. The deregulation of the electricity market has a significant impact and raises questions about effectiveness and efficiency of the regulators. Committees have concluded that the directions taken are appropriate but that regulators should move faster. The lifetime of five power plants has been extended and in the coming years about 85% of the NPPs will request extension. A recent discussion indicated that new plant applications may be made within 5 years. Interest moves now beyond LWR technology. Generation IV NPPs are being discussed and NRC is quite interested in this; as a regulatory agency they need to prepare for it. Deregulation brings new challenges to the NPPs, as margins must be identified to allow cycle extensions, and to shorten outage periods; the power upratings will exceed 20%. It is essential, in order to meet these challenges, that the fundamental basis for such decisions is well understood. For this the analytical tools need to be used, a sound support basis must be available, the ability for more realistic analysis needs to be added and coupling is needed to make sure safety analysis is comprehensive. Probabilistic analysis should be included as it contributes to a more realistic analysis. Risk analysis tools give now more focus on safety and provide better estimation of the margins.

José Maria Aragonés explained the role NSC has taken to promoting research in line with the needs expressed by industry, regulation and by future new and open developments. The field of coupled neutronics/thermal-hydraulics computer codes has received much attention in recent years. The objective is to develop scientific knowledge needed for the development of advanced modelling techniques for new nuclear technologies and concepts, as well as for current nuclear applications. An active research programme exists for instance in the European Union directed at new types of reactor systems. The NSC makes critical reviews of research in this area, addressing the most critical issues. For instance, how do we go from the detailed analysis to the more coarse mesh approach? How can we, when using 3D nodal/ thermal-hydraulics, go to the identification and analysis of the detailed behaviour of critical fuel pins? Power plant operators need to have access to these details. Also the issue of uncertainty analysis for best-estimate methods needs to be addressed, in particular a common methodology for neutronics and thermal-hydraulics methods need to be developed and used for reasons of coherence. The NSC is glad to report success in providing a “proof of principle” that 3D neutronics and thermal-hydraulics can be coupled in a coherent way. These developments do not lead to new discoveries but provide a wealth of interesting quantitative information on phenomena to be used by NPP operators and for safety analysis purposes.

Kostadin Ivanov then presented the consistent benchmark methodology that has been established based on experience with the PWR MSLB benchmark study. As agreed during the course of the MSLB benchmark project, a special session on "Numerical and computational aspects of the coupled 3-D Core/Plant Simulations: OECD/NRC PWR MSLB Benchmark" is now scheduled for the week of 17-21 June 2001, in the framework of the ANS Annual Meeting in Milwaukee, USA. Fourteen invited presentations, all devoted to the MSLB benchmark, will be made and published in a special issue of Nuclear Technology.

The participants introduced themselves and mentioned their personal and organisational interest in this study. The list of experts having expressed the intention to participate in this project together with the codes they intend to utilise is provided as Annex 1 (25 organisations from 10 countries). Not all of them attended the workshop, but confirmed that they shall provide their contribution. The workshop was attended by 26 participants from 7 countries, representing 23 organisations. The list of participants is provided as Annex 2. R. Kern was unable to attend but he submitted a text with recollections of when the Peach Bottom-2 turbine trip experiments were carried out, in which he had assisted and then interpreted.

The agenda was reviewed and adopted after minor changes. It is provided as Annex 3.

Jorge Solis from PSU presented an overview of the PB2 NPP, the BWR pressurisation transients, and previous analyses of PB2 Turbine Trip (TT) tests. The first published PB2 TT analyses were performed with RETRAN (EPRI NP-1076-SR) and RAMONA (EPRI NP-1869). The observed modelling challenges and the uncertainties of obtained results were discussed. Kostadin Ivanov presented the OECD/NRC BWR TT Benchmark – motivation, background, objectives and involved institutions. The sponsorship is provided by US NRC, NEA/OECD and NEP, PSU. Technical assistance is provided from Exelon and EPRI. K. Ivanov also presented an overview of the benchmark activities. First the status was presented – the first draft of the benchmark Specifications was sent to potential participants, the benchmark ftp site was set up, and the first Benchmark Workshop organised. Three workshops are scheduled during the course of the benchmark activities. The second workshop is tentatively scheduled for October 2001 to be hosted by PSI, in Switzerland. The third workshop will be held in May 2002 and FZR, Germany, plan to host it. The deadlines for submitting results of different exercises are proposed as follows: June 30 2001 for Exercise 1, August 31 2001 for Exercise 2, and 31 March, 2002 for Exercise 3. Final benchmark reports will be published in the format used in the PWR MSLB Benchmark and as both OECD/NEA and NUREG/CR reports. During the following discussion several participants expressed an opinion that the first deadline proposed is too early. Some participants feel considerable work is needed to set up the models since they need to start from scratch. It was proposed that the schedule be changed for submitting Exercise 1 results to the end of August 2001.

Technical Sessions

Sessions 2 to 5 were focused on technical issues connected with the first draft of the Benchmark Specifications and the definition of three exercises. The information needed for the exercises was clearly presented to the participants in order to be able to proceed with the calculations in an efficient and timely manner.

Tom Downar from Purdue University chaired session 2. Kostadin Ivanov in his presentation reviewed the received comments from the participants in the benchmark. These comments were mostly participants opinions expressed in regard to the purpose of the second exercise. Two approaches were discussed – coupled 3-D kinetics/core thermal-hydraulic boundary conditions (BC) modeling and 1-D kinetics thermal-hydraulic system calculations. Based on a preliminary survey of participant's opinions, interests and capabilities both options have been included in the second exercise as described in the Draft of the Specifications. Francesco D'Auria expressed an opinion that the Exercise 2 might be critical owing to the need to impose fluid-dynamic conditions across the core. In addition, the effort needed even to analyse all the data from all the participants might not be justified in terms of technical feedback. It is better to fix very well Exercise 1 and to limit the benchmark exercises to the proposed Exercises 1 and 3. The purpose of Exercise 1 is to initialise the system thermal-hydraulics model since the dynamic core response will be modeled using a power vs. timetable or reactivity vs. timetable. Andrés Gómez suggested that a 1-D kinetics exercise is necessary because his organization wants to find out if it is worth changing from 1-D to 3-D kinetics modeling. Further Jorge Solis presented and discussed the thermal-hydraulic data and modeling issues as included in the Draft of the Specifications. The provided thermal-hydraulic data is a combination of the data extracted from the EPRI reports (EPRI NP-563 and EPRI NP-564), PECO topical report (PECo-FMS-0004-A), the basic PECO PB2 RETRAN deck (for which a skeleton deck is provided as Appendix B in the Specifications), and the PSU TRAC-BF1 deck. During the following discussion some participants pointed out that there are some errors in the RETRAN skeleton input deck. Figures and more detailed drawings are still necessary. In order to provide the participants with all the necessary information to build their models it was decided that the two EPRI reports would be made available to participants for the purposes of this benchmark. Andy Olson has also provided PSU with the electronic file of the RETRAN deck, which was tuned especially for the modeling of PB TT2 test. Most of the details of the PB2 model for the benchmark can be found in this model. This model is made available at the benchmark ftp site under directory Specifications. Note that vessel fluid volumes provide fluid space (empty space occupied by liquid or water or a mixture of them). Several modeling issues were discussed further: 1) Critical flow in system bypass valves – Andy Olson explained that there is no choked flow through this valve. This is left to the code capabilities. Some explanation should be included in the specifications about the way they are modeled; 2) Turbine Stop Valve – they can be modeled as one lumped valve or separately. Total pressure drop should be also provided to the participants to make the calculations as consistent as possible; 3) The RETRAN steam line modeling raised questions about the accuracy of the model. Some participants think that a more accurate model should include the modeling of the four steam lines instead of lumping them together in an average one. Andy Olson believes that enough accuracy is obtained by using the RETRAN approach; 4). The RETRAN model includes the two recirculation loops. This model could also be lumped into a single one since the system did not play an important role during the transient. The RETRAN model lumps the 20 jet pumps into just two (ten per recirculation loop); 5) Additional information needs to be provided in the Specifications about the initial reactor water level and reactor (Dome) pressure using the P1 data (these measured values are very accurate) and about the inlet sub cooling; 6) Jet pump modeling is an important issue especially for participants who do not have special models in their thermal-hydraulics codes. Andy Olson have agreed to provide jet pump flow and further discussion on this model was postponed for the final session; 8) With regard to the Thermo-Physical and Heat Transfer Characteristics as presented in the Specifications, some participants noted that the units for fuel density as well as the units for thermo-physical constants should be checked.

Akitoshi Hotta from TSI Inc., Japan, chaired session 3. In two consecutive presentations Baris Sarikaya from PSU presented and discussed in detail the core neutronics model and coupling with thermal-hydraulics as well as cross-section libraries and modeling as included in the Draft of the Specifications. One of the questions raised was whether the details of the proposed core neutronics model and associated exposure and history effect approximations are sufficient for accurate reconstruction of the initial steady state. K. Ivanov informed participants that the PSU benchmark team has verified the model for the initial steady state by code-to-code comparisons with SIMULATE-3 and the measured data. The results obtained are in good agreement and justified the use of the proposed model, which seems to be good compromise between accuracy and computational efficiency (in terms of CPU-time and memory). Baris Sarikaya also addressed the remaining issues to be re-solved, where the participants' suggestions and agreement are necessary. These issues are utilisation of Assembly Discontinuity Factors (ADFs) in 3-D core calculations, Xenon effect modeling, and consistency of procedures for 1-D cross-section generation to be used by different thermal-hydraulics models/codes. In regard to the last issue Andy Olson provided a description of the PECO 1-D cross-section generation procedure, presented at the Fifth International RETRAN Meeting, Washington D.C., 1989 (A. Olson, "Methods for the Generation of 1-D Reactor Kinetics Utilizing the SIMULATE-E/SIMTRAN-E Computer Code Sequence"). During the discussion the following issues were addressed: 1) BWR reflector modeling - in order for the reflector regions to be represented with reasonable accuracy three regions need to be considered: lower plenum region, radial reflector water, and upper plenum region. This is the approach used in the Draft of Specifications. The minimum thickness of the water reflector is 2 inches of water; 2) Core bypass flow and its importance for the feedback modeling: the out-channel moderator temperature in the reactor core is closer to the reflector region. Out-channel flow should be included in core bypass flow modeling because it is important for feedback purposes. Additional information has to be provided to include geometry and percentage of flow rate through this region; 3) Cross-section modeling: history and instantaneous feedback dependence. Internal (in-channel) void distribution has a non-linear feedback effect and the in-channel flow modeling is important. Jorge Solis presented further the Benchmark Exercises as defined in the Draft of Specifications: purpose of each exercise, input data, involved models, and initial and boundary conditions. Exercise 1 is defined as power (or reactivity) versus time plant simulation with fixed axial power profile table; Exercise 2 – Coupled 3-D kinetics/Core thermal-hydraulic model and/or 1-D kinetics plant system simulation; and Exercise 3 – Best-estimate coupled 3-D Core/Thermal-hydraulic system modeling. During the following discussion Birol Aktas proposed to perform the tree PB2 turbine trip tests because they would provide more information on code capabilities. Andy Olson mentioned that the benchmark information (on exercises) should be kept to a minimum because if the three tests have to be analysed, the work requirements (analysis) would be enormous. Turbine Trip 2 experimental data is the most reliable set. The other tests were contaminated (initial and transient conditions). Participants could model the three tests; however for the comparison purposes only TT2 should be used. Francesco D'Auria asked whether it is possible to provide relative axial power distribution on a one-by-one channel basis. Further this proposal was extended to the provision of a more realistic power distribution in the thermal-hydraulic channels during the transient. With regard to Xe effect modeling Andy Olson explained that the initial tests were steady state and therefore there is no need to take into account the Xe effect explicitly. José María Aragonés suggested that Exercise 1 should be defined as "Guided thermal-hydraulics exercise", while Exercise 2 as "Guided neutronics exercise". Akitoshi Hotta suggested that Exercise 1 should be kept as simple as possible.

Francesco D'Auria from the University of Pisa, Italy, chaired Session 4. In his presentation Andy Olson discussed the Exelon experience in analyzing of PB-2 TT tests. The analysis was performed with RETRAN-02 with 1-D kinetics and it is documented in the PECO Energy Topical Report (PECo-FMS-0004-A). The results are generally good with accurate prediction of pressure and power response. Andy Olson discussed further the analysis approach used (first develop an accurate thermal-hydraulic model then develop kinetics model and finally perform a coupled calculation) with emphasis on the difficulties in this type of analysis (a rapid pressurisation in a BWR, which requires a tightly coupled simulation) and limitations of 1-D kinetics model. The key TT2 transient modeling parameters were also identified and discussed in detail. Akitoshi Hotta presented the TSI experience in PB2 TT test simulations using the coupled code TRAC-BF1/ENTRÉE. He focused on evaluation and uncertainties of 1-D cross-section, and some issues connected with coupled 3-D kinetics/system thermal-hydraulics modeling as neutronics/thermal-hydraulics spatial mesh overlays, and the impact of Assembly discontinuity factors (ADFs) on obtained results. In his presentation Tom Downar presented the developed TRAC-M/PARCS models for PB2 TT2 simulation and some preliminary steady state and transient results. Upon the participants' request, he also informed participants about the current status of the NRC merged code TRAC-M/PARCS and the completion schedule. Birol Aktas from ICL Inc. summarised the calculations performed in order to develop TRAC-M model for PB2 NPP. The initial work was focused on two areas: description of geometry and initial and boundary conditions at rated power and for TT2 transient. The description of geometry included recirculation loops (recirculation pumps, and jet pumps), reactor vessel, steam lines, separators and dryers, and reactor core. An outline of the jet pump model was presented in detail in order to help participants whose codes do not have special jet pump models, in order to be able to develop one. Bernard Karrasch from Siemens Nuclear discussed in his presentation the two-phase heat transfer during a TT event. The Siemens analysis experience of TT events indicates that the two-phase transfer is an important issue and it is difficult to describe it in a best estimate way. Richard Kern contributed to the Workshop with a paper discussing the NETCORP experiences relating to BWR pressurisation events. This paper includes the DNB/3D code description and BWR models used to analyse BWR pressurisation events. Fumio Kasahara from INS/NUPEC presented the analysis experience of BWR TT and PB-2 TT tests at NUPEC. Several differences were found between the obtained results and the measured data, which helped to identify the limitation of appropriate analyses using point kinetics approximation. The new PB-2 TT benchmark calculations will be performed using SKETCH-INS/TRAC-BF1.

Andy Olson from Exelon chaired Session 5. Jorge Solis in his presentation discussed the reference results, which for this benchmark will be a combination of measured data and reference calculations. During the following discussion Andy Olson reviewed the available measured data in terms of quality and, based on the PECo experience, he recommended which data should be used for reference results in this benchmark. The measured data for the initial steady state conditions are taken primarily from P1 computer process data. The measured recirculation flow at initial conditions is wrong. More information should be provided for the recirculation pump modeling. The core pressure drop calculated by process computer includes the entire core. Measured pressure drop is the pressure drop across the core plate. Kostadin Ivanov presented the requested output and output format, as described in the Draft of Specifications. He discussed further the proposed methodology for comparative analysis of participants' results. A difference from the previous PWR MSLB benchmark is that the BWR TT benchmark involves not only code-to-code comparisons but also code-to-data comparisons. This difference implies that the proposed methodology must be able to account for the experimental uncertainties. The suite of statistical techniques developed in-house by PSU for the PWR MSLB benchmark was successful for the analysis of single values, 1-D and 2-D distributions. However, it did not involve a comprehensive and sophisticated analysis of the time evolution comparisons. To address these issues it is proposed that, for the purposes of this benchmark, the Automated Code Assessment Program (ACAP), developed by ARL, PSU for US NRC, be used. K. Ivanov presented the modeling features, and application examples of ACAP.

Jose Maria Aragonés from UPM chaired Session 6. It was the discussion session and Andy Olson and Kostadin Ivanov assisted him. In general, the discussion was mainly focused on the benchmark specifications and on the schedule of activities. The following is a summary of the most important aspects that need further review:

1) THERMAL-HYDRAULIC MODELING ISSUES:

Participants expressed an opinion that the impact on the results of the bypass flow region modeling must be quantified. Usually it is accepted that in a BWR about 2% of fission power is released as direct gamma heating to the in-channel coolant (flow) and about 1.7 % to the bypass flow. During the transient the bypass liquid stays sub-cooled and there was not observed (by calculation) any voiding in the bypass region was observed during the TT tests. Thermal-hydraulic characteristics of the different bundle types must be clarified in the Final Specifications (EPRI report contains this information for each of the bundle types). Andy Olson explained that the bypass flow properties are a function of fuel design. There are different bypass flow paths for 7x7 and 8x8 assembly types. The following additional information is requested to be included in the Final Specifications: total core pressure drop; friction loss coefficients for the axial pressure distribution (from inlet to exit of the core); total and bypass flow values; and bypass flow distribution in the core. With regard to the Jet-Pump Modeling - Birol Aktas showed the participants some modeling options to include the jet-pumps to the codes that do not have this capability. Andy Olson proposed that the participants use the code control system to emulate the dynamics of the jet-pumps. Participants requested a write-up for the jet-pump model to be put on the benchmark site.

2) CORE NEUTRONICS AND CROSS-SECTION MODELING ISSUES:

The cross-sections in the benchmark libraries are generated homogenising the bypass flow associated with the lattice. One way to account for the impact of bypass flow is to use the method presented by Akitoshi Hotta in his presentation with a recommendation to use a constant value. It may be important when comparing the initial steady state axial power distribution.

The generated cross-section tables include Assembly Discontinuity Factors (ADFs):

1. ADFs are generated and provided in the tables. Two values are provided: for wide and narrow gaps.

2. Form functions and corner discontinuity factors are not considered in this benchmark because, there is no experimental information to compare with on the pin-by-pin level. However, this information can be generated and provided to the participants who want to perform such a calculation.

Delayed Neutron Parameters will be provided per cross-section set since they are burnup dependent. They are constant per cross-section set. They are not dependent on the instantaneous feedback parameters.

With regard to Xe-effect - transient simulations showed that equilibrium values do not affect the results. It is possible they could play a role during initial steady state (K-eff, axial power distribution, etc.). Cross-section tables provide enough information to calculate the initial xenon content.

3) BENCHMARK EXERCISES:

Francesco D’Auria questioned the usefulness of Exercise 2. Some participants commented about the importance of the core thermal-hydraulic boundary condition model. It was generally agreed that this exercise would help to test the core neutronics and thermal-hydraulic model. Jose-Maria Aragonés suggested that the 1-D kinetics option of Exercise 2 should be considered as an Exercise 3 option.

Hot zero power (HZP) condition steady state calculation was proposed as a part of Exercise 2. A question was raised about the range of the developed cross-section library table look-up. Also some participants were concern about HZP conditions. They were unsure if these conditions are physical for a BWR. The answer was that these conditions could be obtained when most of the control rods are inserted. This HZP state would provide “clean” initialisation of the core neutronics models since the thermal-hydraulic feedback is spatially uniform across the core. The experience gained in the PWR MSLB benchmark indicated the usefulness of such steady state calculation with “fixed” thermal-hydraulic parameters. Therefore the definition of Exercise 2 will be updated to include a near critical state for code-to-code comparison with defined control rod patterns for HZP conditions.

It was generally agreed that Exercise 2 (limited to core boundary condition model) would be set up as follows:

1. Steady state hot zero power initialisation
2. Initial steady state for performing the transient

3. Transient scenario

1-D neutronics could be used in combination with the core boundary condition model. The 1-D kinetics option is included in the benchmark because some of the participants want to use this model to perform the turbine trip benchmark. The problem of 1-D kinetics is the inconsistency that would arise because of different thermal-hydraulics modeling used for collapsing 3-D cross-sections to 1-D cross-sections and the participants thermal-hydraulic models (for example two phase flow model vs. drift flux model, etc.) Boundary conditions will be provided as calculated best estimate system results.

It was noticed that Exercises 1 and 2 could be developed in parallel. In the meantime the 1-D kinetics case will be defined as option for Exercises 2 and 3. It was also noticed that just two types of 1-D cross-sections libraries were needed: for TRAC and RETRAN models. These libraries are going to be developed by PSU.

Some participants asked if the three turbine trip tests were going to be used for the benchmark. Andy Olson said that the general transient characteristics were very good just for turbine trip transient test 2. The existent database for the transient is the cleanest of all the tests. The efforts should concentrate on turbine trip 2. It would be better instead to analyse the other two tests to introduce some extreme versions of the TT2 transient scenario that would provide the opportunity to test better the coupling and feedback modeling. These variations will be part of Exercise 3 and are defined as follows:

1. Turbine trip without bypass system relief opening (would increase the power peak and provide enough pressurisation for safety/relief valve opening)

2. Delay the reactor scram (would produce a second power peak and would be a challenge to the coupled code predictions)

3. Combined extreme scenario - turbine trip without bypass system relief opening and reactor scram delay (the preliminary results indicated that this case is very close to super-prompt-critical and should make a good case for code-to-code comparisons.

In general it was agreed that not opening the bypass system was more realistic. The calculation time would be ten seconds in the above-described three hypothetical cases variations of the TT2 scenario. Safety/relief valves data will be included in the Specifications.

Exercise 3 becomes then coupled core neutronics/thermal-hydraulic system modeling (either 1-D and 3-D kinetics can be used). Since 1-D and 3-D kinetics models are allowed, also point kinetics could be used to perform the system transient calculation. It was generally accepted.

The discussion then concentrated on the type of information provided to the participants to perform the different Exercises. Exercise 1 is proposed to test the system thermal-hydraulics. It was agreed that this exercise is very similar to point kinetics and it can be modeled in two ways: with fixed axial shape or allow power shape to vary. In the latter case an amplitude function should be provided. The initial time for scram plus the time delay will be used for the Third Exercise. Andy Olson explained that in the TT2 test, the feedback turned around the power peak and the scram effect was later and additional to the thermal-hydraulic feedback (void feedback plays the major role while the Doppler feedback plays a sub-ordinate role). If the high neutron flux set point is used it can affect the comparisons of the coupling and feedback models in the most interesting interval of the transient.

Based on the MSLB benchmark experience and in order to help the participants, it was proposed to obtain a quick response to some of the questions they might have by creating a Fast Answer and Question (FAQ) e-mail forum via the OECD e-mail service.

4) OUTPUT REQUESTED AND REFERENCE RESULTS:

The following suggestions were made during this discussion: total core flow used for comparison must include bypass flow. Core inlet enthalpy instead of core inlet sub cooling must be specified for steady state comparison. During the transient the fission power was measured and this parameter should be used for comparisons (not the total power). If 5.0 seconds is the total transient simulation time, a total of 101 time history points should be requested from the participants if the results are be compared each 0.05-second during the transient. Experimental measurements were taken each 0.006 second. Therefore, this time interval should be considered instead. For the two additional versions of the transient scenario of Exercise 3 the transient time should be higher than 5 seconds – for example 10 seconds - in order one to be able to see the effect of steam relief valves. The trip time and trip delay should be specified for both Second and Third Exercises. Pressure comparisons must be performed during the initialisation process (steady state) at different specified locations (steam line, bottom of the core, top of the core, etc.). These locations should be given in the Specifications. Power comparison should be performed for some channel (bundle) locations. The location of this channel/bundle should be defined in the Specifications.

The usefulness of the LPRMs (local power) measurements was discussed. In order to compare code results to the LPRM data, participants need consistent algorithms to model LPRM response. These models need to include microscopic detector cross sections, which should be provided in the benchmark cross-section libraries. LPRMs response model was described in the Akitoshi Hotta’s presentation. Further Andy Olson underlined again that the APRM data is based on the neutron flux measurement, i.e. it does not include the decay heat power. In this way this data have to be compared with participants’ code predictions for fission power.

Jose-Maria Aragonés further suggested, when analysing a given parameter in the form of 1-D or 2-D distributions, the use of standard deviation of the whole distribution, not just at a given point.

5) SCHEDULE:

The discussion was focused on the deadlines and organization of next Workshops. January 2000 - cross-section libraries, Final Specifications, and EPRI reports are distributed through a CD-ROM and the use of the benchmark ftp site. Participants should submit Exercise 1 and 2 results by the end of August 2001. The Second Workshop will be hosted by PSI and is scheduled for October 15 and 16, 2001. Participants should submit Exercise 3 results by the end of March 2002. The Third Workshop will be hosted by FZR, Germany, and it is tentatively scheduled for May 2002.

CONCLUSIONS

Future Workshops

Two more workshops are scheduled for completing the programme of work. The second will be hosted by the Paul Scherrer Institute (PSI), Villigen, Switzerland from 15-16 October 2001 and the final one will be held at the Forschungzentrum Rossendorf, located near Dresden, Germany, in May 2002.

The titles of the papers presented at the meeting are provided as Annex 4. The full texts are available to participants and can be downloaded from:

Address: varna.me.psu.edu
ID: bwrtt
PASSWORD: tt2000

List of actions and deadlines:

Dates	Action
15 January 2001:	final specification is sent out including a CD-ROM with specification, data and background reports.
31 August 2001:	deadline for submitting results from phase I & II
15-26 October 2001:	Second Workshop at PSI, Villigen Switzerland
31 March 2002:	Deadline for submitting Phase III results
April/May 2002:	Third Workshop at FZ Rossendorf near Dresden, Germany

Annex 1

Codes used in BWR-TT Benchmark
(BWR Turbine Trip Benchmark Workshop I, 9-10.XI.2000 Philadelphia)

Name	Establishment	Code(s)
FINLAND		
* DAAVITTILA, Antti	VTT	TRAB-3D
FRANCE		
MIGNOT, Gerard	CEA-CADARACHE	CATHARE/CRONOS/FLICA
* RAMEAU, Brigitte	CEA-CENG	CATHARE/CRONOS/FLICA
ROYER, Eric	CEA-SACLAY	CATHARE/CRONOS/FLICA
GERMANY		
GRUNDMANN, Ulrich	FZR	DYN3D/ATHLET
KARRASCH, Bernhard	KWUERLANG	S-RELAP5/RAMONA5
SCHMIDT, Klaus Dieter	GRS	ATHLET-Quabox/CUBBOX
* VELTEN, Roger	KWU	
ITALY		
D’AURIA, Francesco	UNIPISA	RELAP-5
JAPAN		
* ARAYA, Fumimasa	JAERI	TRAC-BF1/MLK3D
* ASAHI, Yoshiro	JAERI	THYDE-NEU
FUJII, Toshihiro	TOSHIBA	TRACG
HOTTA, Akitoshi	TODEN	TRAC/BF1-ENTREE
KASAHARA, Fumio	NUPEC	SKETCH-INS/TRAC-BF1
NAGAYA, Yasunobu	JAERI	TRAC-BF1/MLK3D
SPAIN		
ARAGONES BELTRAN, Jose M.	DIN-ETSII	SIMTRAN/RELAP-5
* DE LA RUA, Carmen	NUCLENOR	TRAC-BF1/MOD1 V1
GOMEZ, Andres J.	IBERINCO	RETRAN-3D
SWEDEN		
* ERIKSSON, John	STUDSVIK	RELAP-5/PARCS
SWITZERLAND		
FERROUKHI, Hakim	PSI	RETRAN-3D/TRAC-BF1
CHINESE TAIPEI		
* KAO, Lainsu	INER	RETRAN-3D/SIMULATE-3K
UNITED STATES OF AMERICA		
AKTAS, Birol	ISLINK	TRAC-M/PARCS
DONOVAN, Kevin	EXELON Corp.	-
DOWNAR, Thomas J.	UPURDUE	TRAC-M/PARCS
* GOSE, Gary	CSAID	RETRAN-3D
HUNT, Kenneth W	EXELON Corp.	-
IVANOV, Kostadin	PSU	TRAC-BF1/NEM
KERN, Richard C.	NETCMD	DNB/3D
LEIKER, Jon D.	WESTINGHOUSE	
OLSON, Andy	EXELON Corp.	RETRAN-3D
* PETERSON, Craig	CSAID	RETRAN-3D
PRUITT, Douglas W.	SIEMENSWA	
SARIKAYA, Baris	PSU	TRAC-BF1/NEM
SOLIS RODARTE, Jorge	PSU	TRAC-BF1/NEM
THADANI, Ashok	NRC	-
International Organisations		
SARTORI, Enrico	OECD/NEA	-

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* not attending the workshop

Annex 2

OECD/NRC BOILING WATER REACTOR TURBINE TRIP BENCHMARK – FIRST WORKSHOP

Philadelphia, USA
9th - 10th November 2000

Hosted by
Exelon Generation

List of Participants

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* regret not to have been able to attend

Annex 3

OECD/NRC BOILING WATER REACTOR TURBINE TRIP BENCHMARK – FIRST WORKSHOP

Philadelphia, USA
9th - 10th November 2000

Hosted by
Exelon Generation

FINAL PROGRAM

November 8th

19:00 – 21:00 Welcome Reception and Registration – *Kenneth Hunt*

November 9th

Session 1 – Session Chair – *Enrico Sartori*

08:00-08:30 Introduction and Welcome (Exelon Generation, US-NRC, and OECD-NEA) - *Kevin Donovan, Ashok Thadani, and José-Maria Aragonés*
08:30-09:00 Overview of the PB-2 Reactor and TT Tests. Previous Analyses of the PB-2 TT Tests - *Jorge Solis*
09:00-09:30 OECD/NRC BWR TT Benchmark – *Kostadin Ivanov*
09:30-10:00 Overview of the Benchmark Activities – Status and Schedule – *Kostadin Ivanov*

10:00-10:15 Coffee Break

Session 2 – Session Chair – *Tom Downar*

10:15-10:45 Comments on BWR TT Benchmark – *Kostadin Ivanov*
10:45-12:00 Discussion of Benchmark Specifications – Thermal-Hydraulics Data and Modeling – *Jorge Solis*

12:00-13:00 Lunch

Session 3 – Session Chair – *Akitoshi Hotta*

13:00-14:00 Discussion of Benchmark Specifications – Core Neutronics Model and Coupling with Thermal-Hydraulics – *Baris Sarikaya*
14:00-14:30 Discussion of Benchmark Specifications – Cross-Section Libraries and Modeling - *Baris Sarikaya*
14:30-15:00 Discussion of Benchmark Specifications – Benchmark Exercises – *Jorge Solis*

15:00-15:15 Coffee break

Session 4 – Session Chair - *Francesco D'Auria*

15:15-15:45 PECO Experience in Analyzing of PB-2 TT Tests – *Andy Olson*
15:45-17:45 Presentations by Participants on Their Experience and Results of Analysis of BWR TT Transients:

- TSI, Japan (A. Hotta)
- U-Purdue-NRC, USA (T. Downar)
- SIEMENS/KWU, Germany (B. Karrasch)
- NUPEC, Japan (F. Kasahara)
- ISLINK, USA (B. Aktas)

November 10th

Session Five – Session Chair – *Andy Olson*

08:00-09:00 Discussion of Benchmark Specifications – Reference Results – Combination of the Available Experimental Data and Reference Calculations – *Jorge Solis*
09:00-09:30 Discussion of Benchmark Specifications – Requested Output and Output Format - *Kostadin Ivanov*
09:30-10:00 Methodologies for Comparative Analysis of Participants' Results – Code-to-Data and Code-to-Code Comparisons – *Kostadin Ivanov*

10:00-10:15 Coffee Break

Session Six – Session Chair – *Jose-Maria Aragones*

10:15-11:45 Discussion
11:45-12:00 Conclusion and Closing Remarks

Annex 4

List of papers presented / distributed at the first BWR-TT Workshop

1. Final Announcement of Workshop
2. Final Programme
3. Tentative List of Participants
4. Participants in the benchmark and code systems used
5. Overview of the PB-2 Reactor and TT Tests. Previous Analyses of the PB-2 TT Tests - *Jorge Solis*
6. OECD/NRC BWR TT Benchmark – *Kostadin Ivanov*
7. Overview of the Benchmark Activities – Status and Schedule – *Kostadin Ivanov*
8. Comments on BWR TT Benchmark – *Kostadin Ivanov*
9. Discussion of Benchmark Specifications – Thermal-Hydraulics Data and Modeling – *Jorge Solis*
10. Discussion of Benchmark Specifications – Core Neutronics Model and Coupling with Thermal-Hydraulics – *Baris Sarikaya*
11. Discussion of Benchmark Specifications – Cross-Section Libraries and Modeling - *Baris Sarikaya*
12. Discussion of Benchmark Specifications – Benchmark Exercises – *Jorge Solis*
13. PECO Experience in Analyzing of PB-2 TT Tests – *Andy Olson*
14. Methods for the generation of 1-D reactor kinetics utilizing the SIMULATE-E/SIMTRAN-E computer code sequence, 5th Int. RETRAN meeting, Sept 1989, Washington DC, *Andy Olson*
15. NETCORP experiences relating to BWR oressuruzation events, *R.C. Kern*
16. Experiences of peach Bottom 2 Turbine Trip Test Simulations by TRAC-BF1-ENTRÉE, *Akitoshi Hotta*, TSI, *Hisashi Nimokata* , TIT, Japan
17. 2-Phase heat transfer during a TT event, *B. Karrasch* SIEMENS/KWU, Germany
18. Analysis Experience of BWR-TT and PB-2 TT Tests at NUPEC Japan, *Fumio Kasahara*
19. Discussion of Benchmark Specifications – Reference Results – Combination of the Available Experimental Data and Reference Calculations – *Jorge Solis*
20. Discussion of Benchmark Specifications – Requested Output and Output Format - *Kostadin Ivanov*
21. Methodologies for Comparative Analysis of Participants' Results – Code-to-Data and Code-to-Code Comparisons – *Kostadin Ivanov*
22. Statistical methods used for code-to-code comparisons in the OECD/NRC PWR MSLB benchmark, Annals of Nuclear Energy 27 (2000) 1589-1605, *J. Bryce Taylor, Kostadin N.Ivanov*