# NRC INTERNATIONAL TRIP REPORT

## Subject
5th Meeting of the Organization for Economic Cooperation and Development (OECD) - Nuclear Energy Agency (NEA) Primarkreislauf-2 (PKL-2) Program Review Group (PRG) and Management Board (MB) and 1st Analytical Workshop

## Dates of Travel, Countries and Organizations Visited
April 24 - 29, 2010, Pisa, Italy

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## Sensitivity
Meeting discussions and materials distributed during these meetings are not sensitive and may be released to the public. However, data generated as part of this experimental program will be kept confidential for a period of three years after the completion of the project. Similarly, future documents may contain proprietary information that will be clearly marked and must be protected as such.

## Background/Purpose
The PKL-2 Project is an international consortium formed and facilitated by the NEA to investigate safety related issues relevant to current and new PWR designs. The experimental focus of the program is on complex heat transfer mechanisms in steam generators and boron precipitation processes under postulated accident conditions. The NEA is a specialized agency within the OECD that fosters the safe and peaceful use of nuclear energy through international scientific partnerships with its member countries.

For the PKL-2 Project, 19 of the 28 NEA member countries have agreed to a program of experimentation that includes eight experiments covering the following topics of interests:

G1. Systematic investigation of the heat transfer mechanisms in steam generators (SGs) containing nitrogen, steam, and water (2 tests)

G2. Cooldown procedures with SGs isolated and emptied on the secondary side

G3. Fast cooldown transients, e.g., main steam line break (MSLB)

G4. Systematic study of heat transfer in SGs under reflux condenser conditions

G5. Boron precipitation processes after large break LOCAs

G6/G7. Subjects have yet to be determined

All of the integral experiments will be conducted in the PKL facility, which is a full height, 1/145 power-volume scaled model of a 4-loop PWR. Smaller scale complementary tests will be conducted at the PMK facility in Hungary and the Rossendorf Coolant Mixing (ROCOM) test facility in Dresden, Germany.

**Abstract: Summary of Pertinent Points/Issues**
The 5th OECD/NEA PKL-2 Project PRG and MB meeting and 1st Analytical Workshop were hosted over a 4-day period by the University of Pisa's San Piero a Grado Nuclear Research Group in Pisa, Italy. The meetings were well attended, with very few absences due to the volcanic eruption a few days earlier in Iceland.

The first two days of the meeting were dedicated to the PRG/MB and focused on discussions about the recently generated data from Test G4, the boundary conditions from the next test to be conducted, Test G5, and the topics for the two open tests, Tests G6 and G7. The results from Test G4 gave a good indication, by heat balance, of the amount of reflux condensate returning to the reactor vessel from the SGs, and for different cooldown rates, showed the conditions under which counter-current flow limiting (CCFL) was established in the hot legs and SG U-tubes. On Test G5, the group moved closer to agreeing on the test boundary conditions, with the NRC, Swedish, and Japanese representatives agreeing to work together to finalize the remaining issues. And finally on Tests G6 and G7, the participants discussed several topic possibilities but no consensus was reached. Each member was asked to continue discussions within their home organizations and to be prepared to provide vetted suggestions during the next meeting.

The final two days of the meeting were dedicated to the PKL-2 project's first Analytical Workshop. This workshop included presentations on simulations performed using different thermal-hydraulic system codes, such as TRACE, RELAP5, and ATHLET, and two simulations performed using the computational-fluid-dynamics code ANSYS-CFX. The NRC staff and members from the Paul Scherrer Institute, the University of Pisa, and the University of Valencia each gave presentations on the post-test calculation of Test G3 using the TRACE code. Each of these presentations showed reasonable to excellent agreement with the test data.

**Discussion:**
The 5th OECD/NEA PKL-2 Project PRG and MB meeting and 1st Analytical Workshop were hosted over a 4-day period by the University of Pisa's San Piero a Grado Nuclear Research Group in Pisa, Italy. The meetings were well attended, with very few absences due to the volcanic eruption a few days earlier in Iceland.

The first two days of the meeting were dedicated to the PRG/MB and focused on discussions about the recently generated data from Test G4, the boundary conditions from the next test to be conducted, Test G5, and the topics for the two open tests, Tests G6 and G7. Good information and discourse developed over these topics and the participants took away ideas to be discussed further within their home organizations.

Test G4, which was conducted over the months of November and December 2009, was a parametric study on the effects of steam generator (SG) secondary-side fill level and secondary-side cooldown rates on heat transfer in SGs under reflux condenser conditions. The test consisted of two runs. In the first run, Run 1, primary-system conditions were held constant while the inventories on the secondary sides of each SG were reduced in a stepwise manner. The preliminary results from Run 1 give a good indication, by heat balance, of the amount of reflux condensate returning to the reactor vessel from the SGs. The results also show that when the secondary-side liquid levels were the highest, a maximum of 40% of the steam inflow condensed in the outlet sides of the SG U-tubes. For each of the lower established liquid levels, the ratio of condensation on the inlet and outlet sides was nearly the same, around 50% on each side.

In the second test run, Run 2, the primary-side pressure was systematically reduced by initiating secondary-side cooldown rates of 500 K, 250 K, and 100 K/hr. Significant results from Run 2 are as follows:

- During each of the cooldown procedures, the primary pressure remained closely coupled to the secondary pressure and significant coolant displacement occurred from the pressure-vessel downcomer into the core region
- As long as feedwater injection was maintained, heat removal from the primary to the secondary was preserved, even at very low secondary-side liquid levels
- Core cooling was always maintained

Test G5 will simulate long-term cooling conditions following a large break loss-of-coolant accident. The objective of this test is to observe the conditions affecting the rate at which boron precipitates and the effectiveness of hot-leg injection as a mitigation strategy. The Operating Agent (OA) was made aware of the NRC staff's position of having the pipe-break be a large split-type break occurring at the top of one of the cold legs and for higher boron concentrations (around 3000 ppm) in the emergency core cooling system (ECCS) injection flows. The OA acknowledged the acceptability of these requests, but emphasized the continued need for consensus, primarily among the US, Swedish, and Japanese members, on the power level, rate of ECCS injection and degree of ECCS subcooling. All concerned parties agreed to discuss their plans by email and communicate the conclusions to the OA before the next meeting.

On the open tests, Tests G6 and G7, the participants discussed several possibilities but no consensus was reached. One possibility discussed at length was to conduct a counterpart of an intermediate break (17%) loss-of-coolant-accident test being conducted in the OECD/NEA ROSA-2 project. The OA, however, did not consider this test a good candidate because the design pressure of PKL is 650 psi, much lower than the 2250 psi capability of ROSA. In order to duplicate the ROSA test in PKL, the transient would have to start at 650 psi, with the conditions down to that point imposed as boundary conditions. Because of the relatively large break size, a number of important phenomena come into play prior to reaching 650 psi, phenomena that would not be captured in PKL. After much deliberation, each member was asked to continue discussions within their home organizations and to be prepared at the next meeting to provide vetted suggestions for test topics.

The final two days of the meeting were dedicated to the PKL-2 project's first Analytical Workshop. This workshop included presentations on simulations performed using different thermal-hydraulic system codes, such as TRACE, RELAP5, and ATHLET, and two simulations performed using the computational-fluid-dynamics code ANSYS-CFX. The NRC staff and members from the Paul Scherrer Institute, the University of Pisa, and the University of Valencia each gave presentations on the post-test calculation of Test G3.1, a main-steam-line-break test conducted in June 2009. Each of these presentations showed reasonable to excellent agreement with test data and sparked discussions about component modeling techniques using TRACE. The NRC presentation focused on the operability of the RELAP to TRACE conversion capability in the Symbolic Nuclear Analysis Package (SNAP) and identified modeling changes that would improve the results. The necessary model changes will be incorporated into the NRC model by the end of July 2010, and the improved results will be added to the PKL-2 Test G3.1 benchmark publication.

**Pending Actions/Planned Next Steps for NRC**

- Finalize boundary conditions for boron precipitation test
- Improve TRACE model for Test G3.1 calculation
- Provide topic suggestions for Tests G6 and G7.

**Points for Commission Consideration/Items of Interest**
The content of this report is not expected to require consideration by the Commission.

**Attachments**
Agendas

**"On the Margins"**
None