PWR PACTEL EXPERIMENTS

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OBJECTIVES

− Use the PWR PACTEL facility in an effective way in nuclear safety research in Finland and internationally
− Validate the PWR PACTEL model for APROS and TRACE codes and use the code models in experiment planning
MOST IMPORTANT RESULTS

- The PWR PACTEL international benchmark exercise in 2011
- The PWR PACTEL facility was accepted to the OECD/NEA PKL Phase 3 project in 2011
- Also several other experiments have been carried out
  - supporting the earlier characterizing experiments
  - experimentally verifying the flow reversal in the steam generator tubes
  - studying the U-leg draining
### PWR PACTEL Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>PWR PACTEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference power plant</td>
<td>PWR / EPR</td>
</tr>
<tr>
<td>Volumetric scale: pressure vessel, steam generators, pressurizer</td>
<td>1:405, 1:400, 1:565</td>
</tr>
<tr>
<td>Height scale: pressure vessel, steam generators, pressurizer</td>
<td>1:1, 1:4, 1:1.6</td>
</tr>
<tr>
<td>Maximum primary / secondary pressure</td>
<td>8.0 MPa / 5.0 MPa</td>
</tr>
<tr>
<td>Maximum primary / secondary temperature</td>
<td>300 °C / 260 °C</td>
</tr>
<tr>
<td>Maximum core power</td>
<td>1 MW</td>
</tr>
<tr>
<td>Number of rod simulators</td>
<td>144</td>
</tr>
<tr>
<td>Maximum rod cladding temperature</td>
<td>800 °C</td>
</tr>
<tr>
<td>Number of primary loops</td>
<td>2</td>
</tr>
<tr>
<td>Number of U-tubes in steam generator</td>
<td>51</td>
</tr>
<tr>
<td>Number of instrumented U-tubes in steam generator 1 / 2</td>
<td>8 / 14</td>
</tr>
<tr>
<td>Average steam generator U-tube length</td>
<td>6.5 m</td>
</tr>
<tr>
<td>Steam generator U-tube diameter / wall thickness</td>
<td>19.05 mm / 1.24 mm</td>
</tr>
</tbody>
</table>

Lappeenranta University of Technology
PWR PACTEL BENCHMARK

- Organized in Lappeenranta by Lappeenranta University of Technology
- Seven organizations from the Czech Republic, Germany, Italy, Sweden and Finland participated in the benchmark exercise
- Blind and open calculation phases
- Four system codes were used in the benchmark simulation tasks
- Two workshops were organized for launching and concluding the benchmark
BENCHMARK EXPERIMENT

- SBLOCA experiment which was performed to study the natural circulation behavior over a continuous range of primary side coolant inventories
- Main parameters
  - primary side pressure 75 bar
  - secondary side pressure 42 bar
  - 155 kW core power
  - Ø1 mm sharp edge cold leg break (about 0.04 % of the PWR PACTEL cold leg cross sectional area)
BENCHMARK EXPERIMENT
BENCHMARK CALCULATIONS

- Began with the blind calculation phase
  - pressure and heat losses and the results of a short characterizing transient available
  - facility modeling
  - blind simulation
- Open calculation phase
  - experiment data was released
  - new simulations
  - several improvements to the simulation models
FOUND ISSUES (1/2)

- Three core channels or ten steam generator U-tubes can be lumped together or modeled separately in smaller groups
  - general trends of the system behavior in the simulations were not strongly dependent on the level of the model details
- The accuracy of the simulation models improved remarkably when the pressure and heat loss information was carefully taken into account in the models
  - the heat losses in the upper plenum had a strong effect on the primary side behavior
  - more detailed adjustment of the pressure losses along the facility resulted in a better simulation of the flow distribution
- Coolant can be single phase water, two phase mixture or single phase steam
  - one has to be careful when interpreting both experimental data and simulation results individually as well as when comparing them with each other
FOUND ISSUES (2/2)

- Amount of non-condensable gases in the primary side caused discussion
- Correct use of the models for critical flow, condensation, and CCFL and the user chosen values of the parameters of the models were also widely discussed
  - values recommended in the code manuals did not suit well in this test in some parts of the facility models
- There is a need for user guidelines or a collection of best practices in modeling for system codes that could be used when different types of transients and situations are to be analyzed
Thank you for your attention