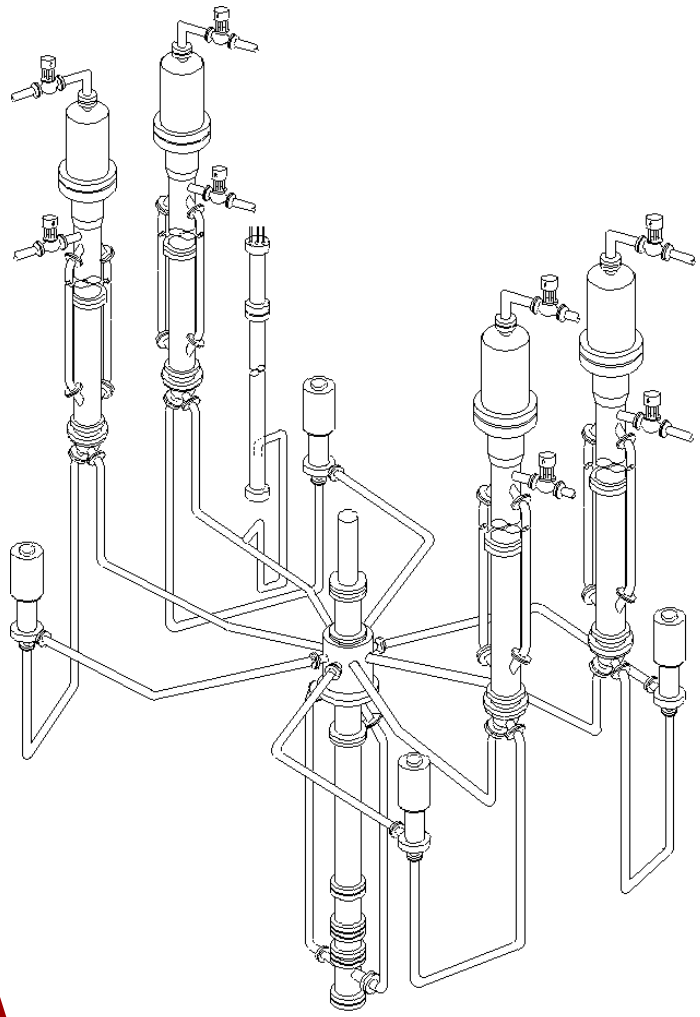
PKL III Test Facility



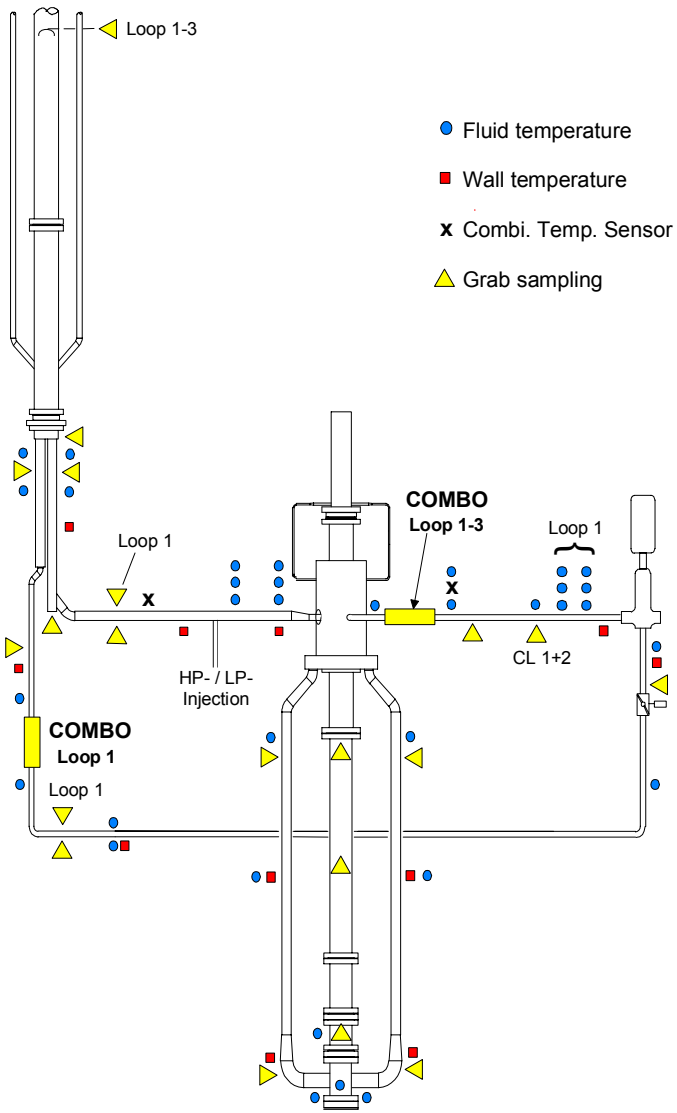
Integral test facility simulating a 1300 MW PWR

- 4-Loop configuration
- All relevant safety and operational systems on the primary and secondary side without turbines and condensers
- Volume and power scale 1:145
- Elevations 1:1

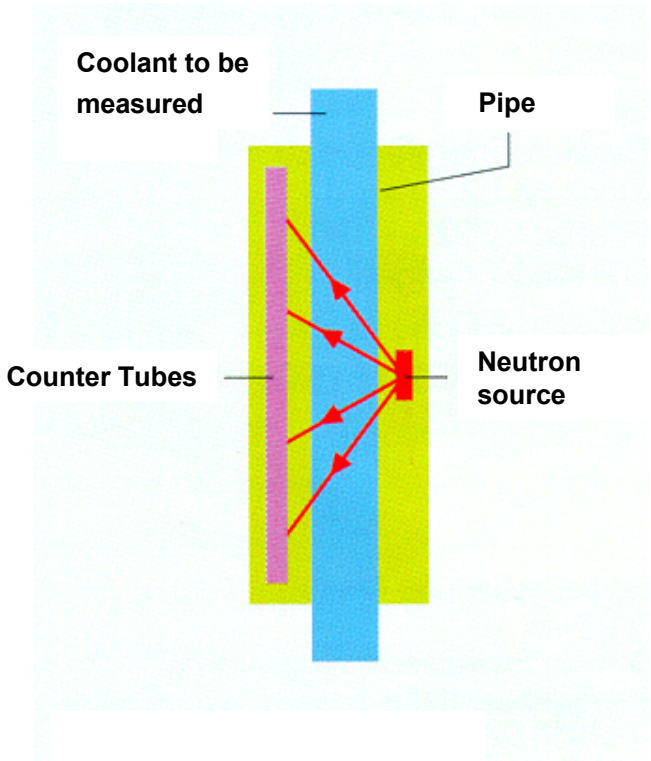
Objectives

- Thermal hydraulic system behavior under accident situations
- Verification and Optimization of cool-down procedures
- Database for the validation of computer codes
- Demonstration of safety margins
- Resolution of safety issues of current interest
- Training of the operating staff

PKL III Boron Concentration Measurements



Continuous Measurement of Boron Concentration (COMBO)



PKL-Tests Concerning Boron Dilution

Background:

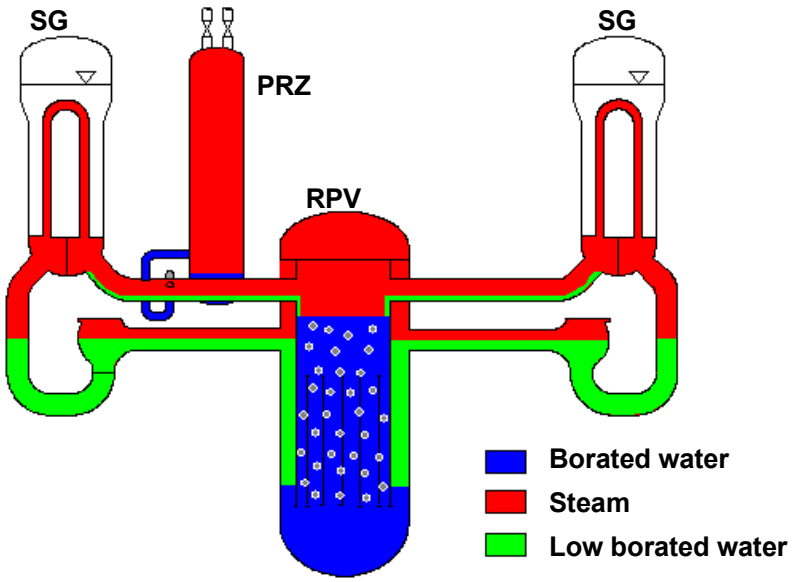
- ***Low borated water entering the core can lead to local recriticality and thereby to a power excursion***
- ***A necessary condition for this to happen is the formation of low borated water slugs in the primary and their transport to the core without sufficient mixing***
- ***Formation of low borated water slugs might occur by separation of borated and almost boron free coolant within the primary, e.g. by***

→ **Small Break and Reflux-Condenser Conditions**

→ **Loss of RHRS under shut-down conditions followed by steam production in the core and condensation in the SG**

PKL-Tests Concerning Boron Dilution after SB-LOCA

Symmetrical injection into all 4 loops (E1.1, E2.1)

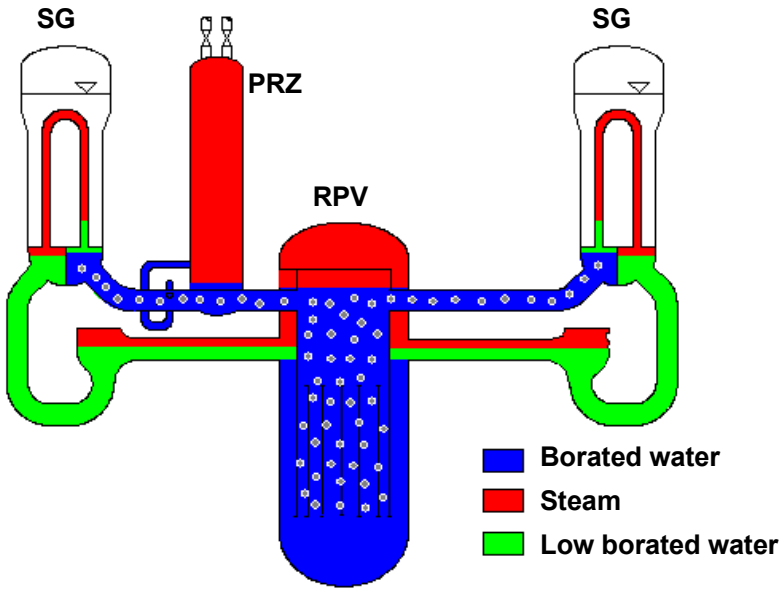


Initial conditions

- *Break in the hot leg of the pressurizer loop (40cm²)*
- *100 K/h cooldown of the SG-secondaries*
- *HP-SIP: into all 4 loops*
  - *E1.1 cold leg*
  - *E2.1 hot leg*
- *Continuous boron concentration measurement (COMBO) at the RPV inlet*
  - *E1.1 in loop 1*
  - *E2.1 in all 4 loops*

PKL-Tests Concerning Boron Dilution after SB-LOCA

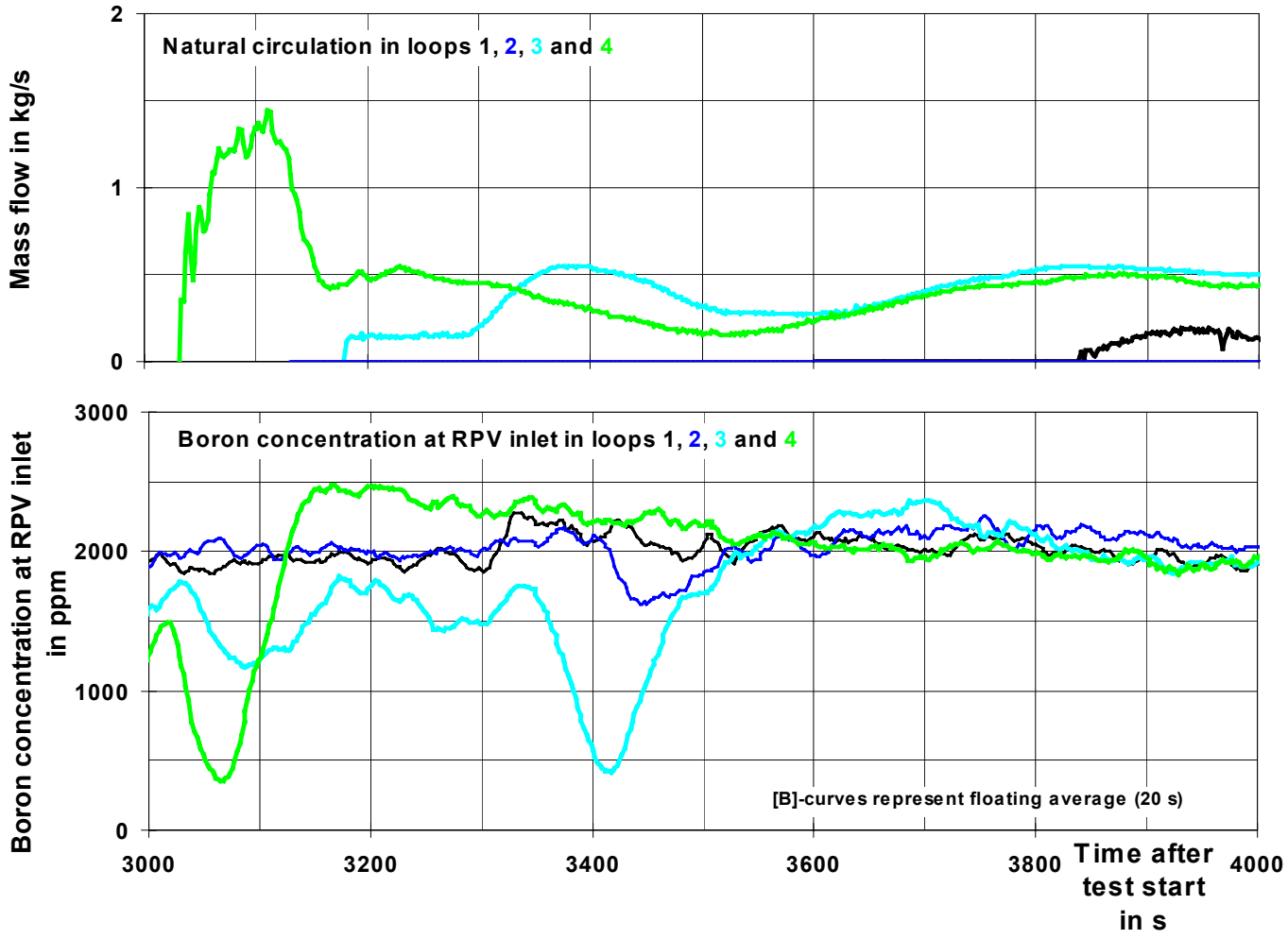
Maximum amount of unborated water: cold leg injection (E2.2)



- *Break in the cold leg of loop 1 (32cm^2)*
- *100 K/h cooldown of the SG-secondaries*
- *2 out of 4 HP-SIPs (cold leg, 1 in break loop)*
- *Continuous boron concentration measurement(COMBO) at the RPV inlet in all 4 loops*

Initial conditions

PKL III E2.2 - Transport of Condensate Slugs due to Restart of Natural Circulation



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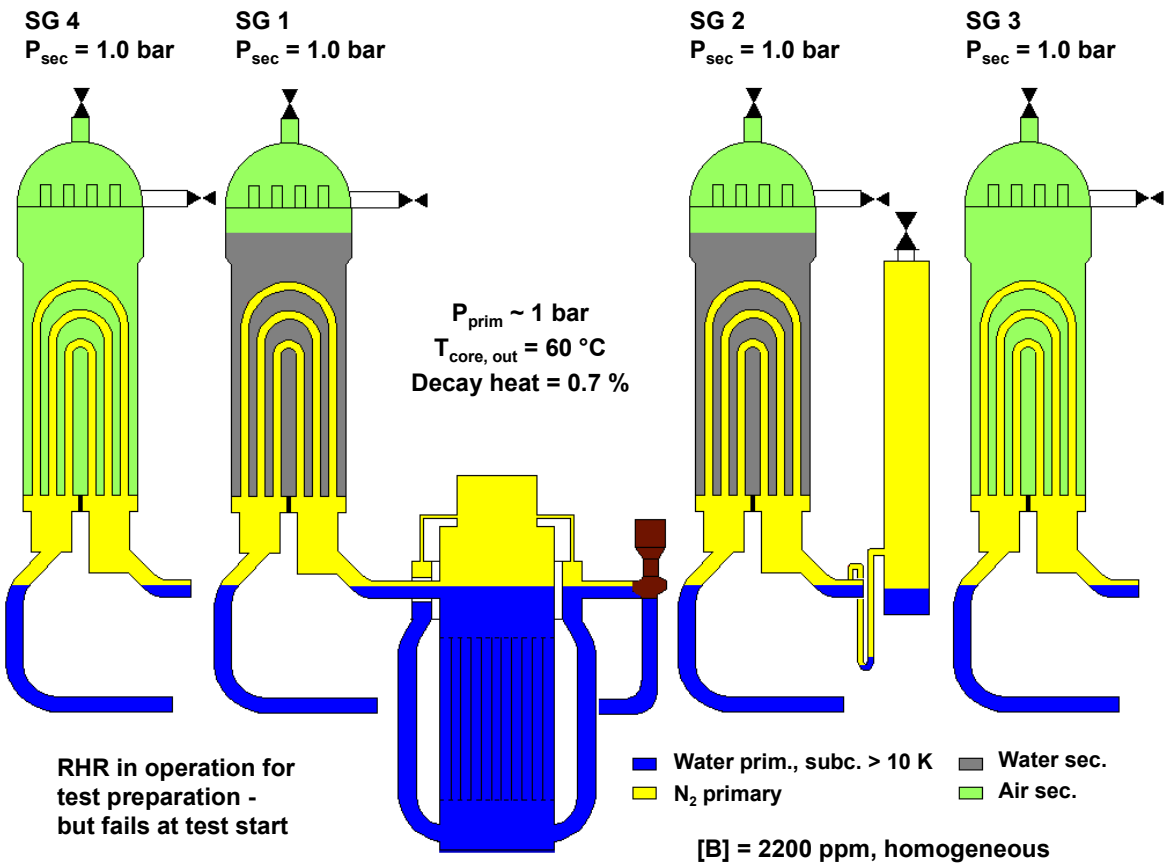
PKL III E3.1: Loss of RHRS

Initial Conditions



Scenario

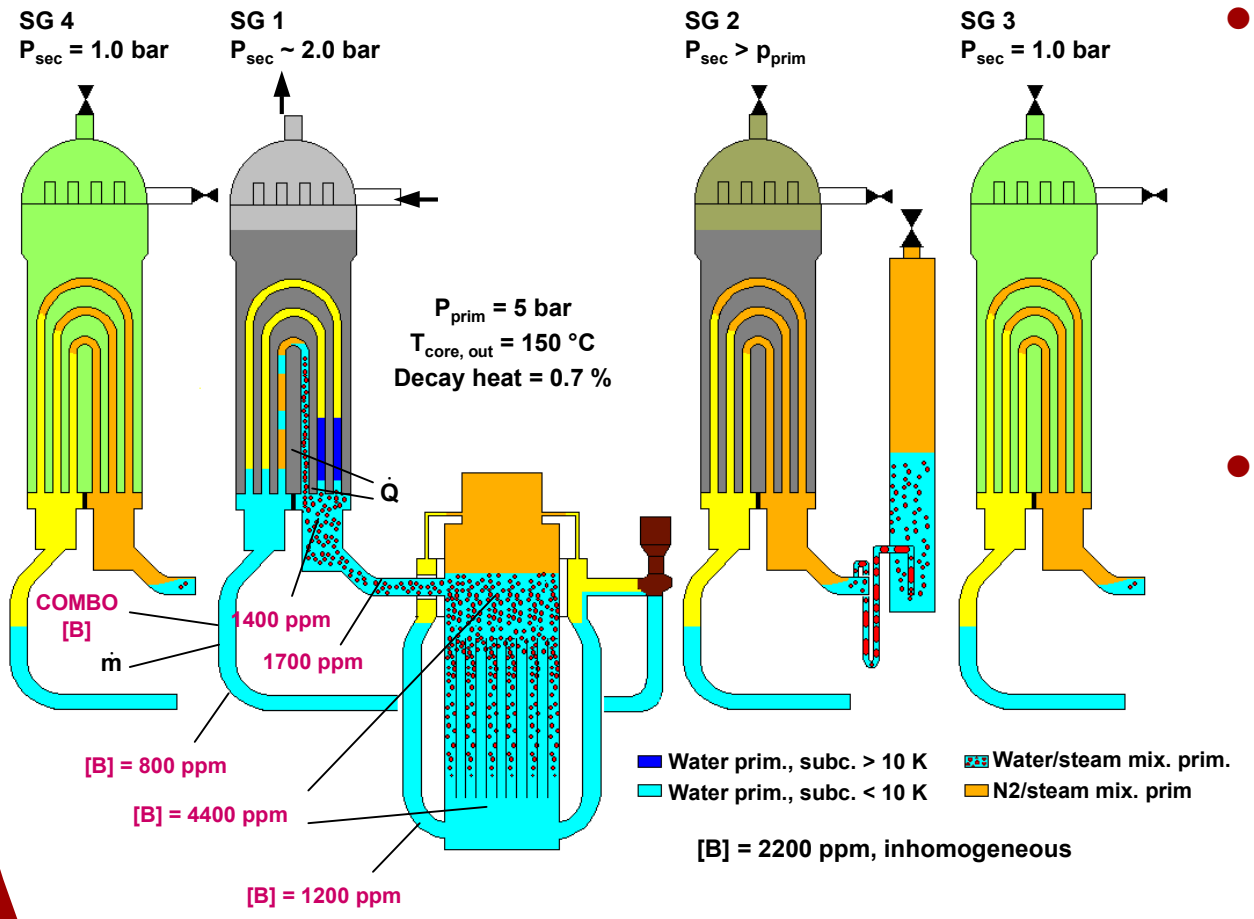
- *Total failure of RHRS when the reactor is shut down, e.g. for refuelling (primary system still closed)*
- *2 SGs filled with water, one of both (SG 1) ready for operation*

Objectives

- *Takeover of residual heat removal by the SG ready for operation*
- *Evolution of local boron distribution*

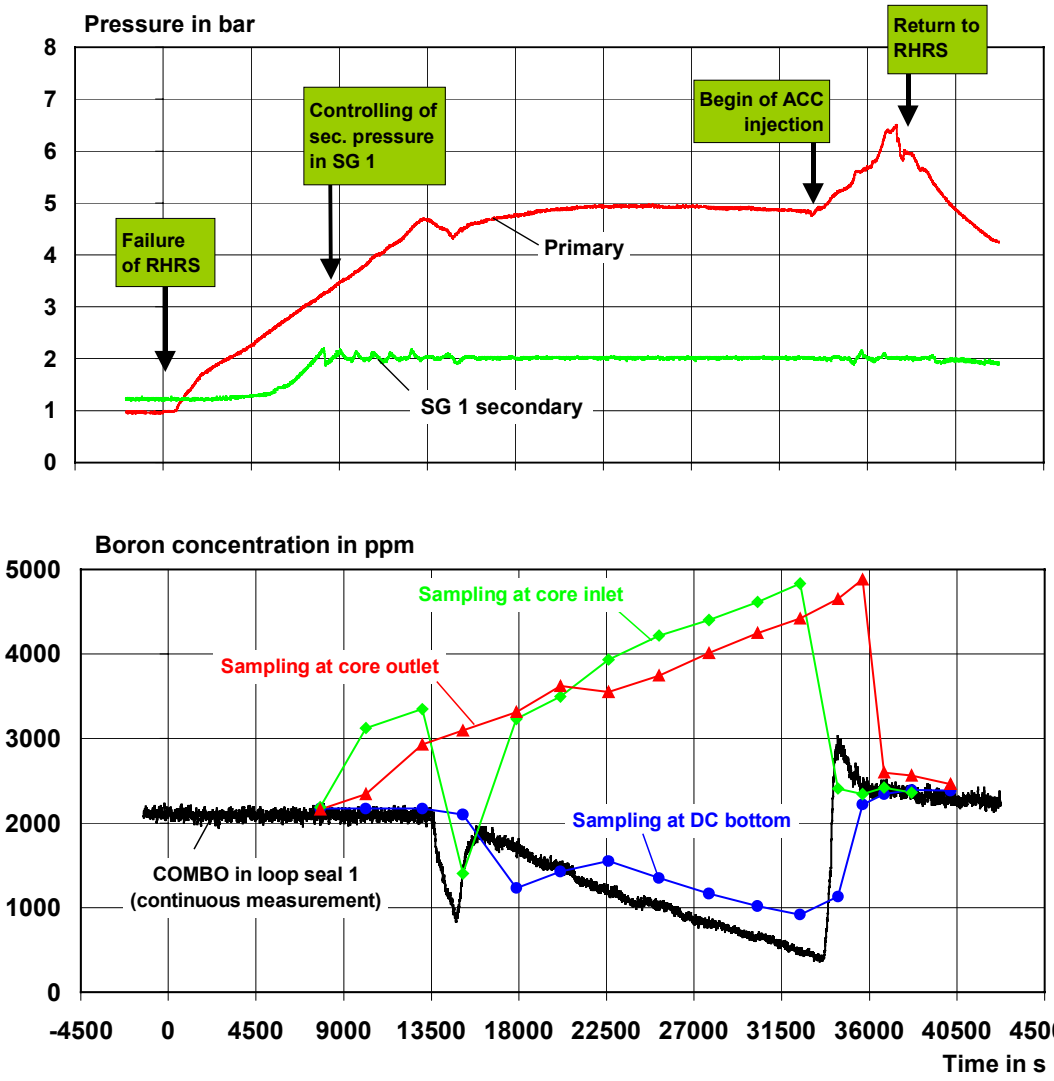
PKL III E3.1: Loss of RHRS

Situation after 7 - 8 hours



- *Failure of RHRS has lead to:*
  - *Core heat up and steam production*
  - *Increase in liquid level and primary pressure*
  - *Condensation in the SGs*
- *Heteregenous behavior in the individual SG U-tubes:*
  - *Slug of subcooled water in the long U-tubes*
  - *Intermittend overflow of low borated condensate in the small U-tubes*

PKL III E3.1: Loss of RHRS



- *Primary pressure stabilizes after about 5 h at 5 bar*
- *Heat transfer by steam production in the core and condensation in the SG in operation*
- *Intermittend overflow of condensate (low borated water) to the cold side in some SG U-tubes*

➔ ***Slow but continuous decrease in boron concentration at the SG outlet and with some delay also in the RPV downcomer***

Application of PKL Test Results to PWR Plants

Use of the PKL Results

- Understanding of the thermal hydraulic behavior during the investigated accident scenarios
  - System behavior
  - Local behavior (e.g. SG tubes)
- Application on NPP operation
  - Contribution to the resolution of a safety issue of current interest (e.g. size of accumulated low borated water is limited and smaller than expected, restart of NC does not occur simultaneously in several loops)
  - Impact on operating procedures
- Support for Code analyses
  - Validation and development of TH system codes
  - Boundary conditions for further experimental and/or analytical investigations on mixing in the RPV downcomer

New Program PKL - 2

- Starting in the second half of 2003
- Program period: 3 years
- 7 Experiments *(partly with several test runs)*

New Program PKL - 2

Proposed Topics of Investigation

(priorities according to comments during 4. PRG and further feedback by the participants)

- *Tests on loss of residual heat removal under shut-down conditions with closed RCS (**3 Tests** with 8 Test Runs)*
- *Tests on boron dilution after SB-LOCAs (**2 Tests**)*
- *Test on loss of residual heat removal under shut-down conditions with open RCS (**1 Test** with 2 Test Runs)*
- *Test on boron precipitation during LB-LOCA (**1 Test**)*