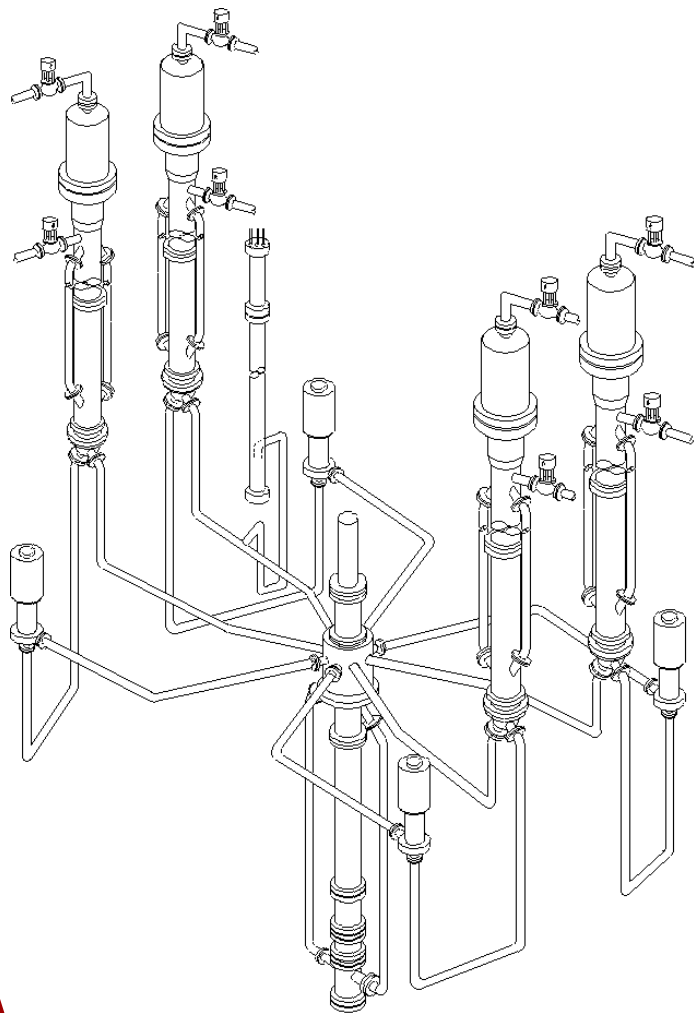


# PKL III Test Facility



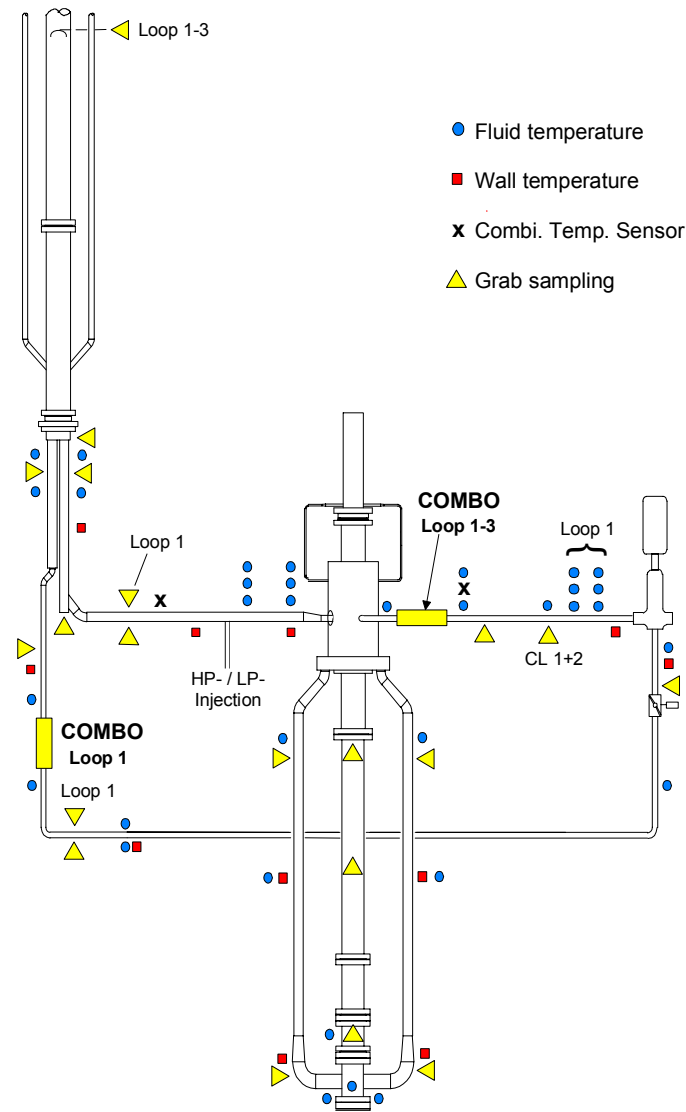
## Integral test facility simulating a 1300 MW PWR

- 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

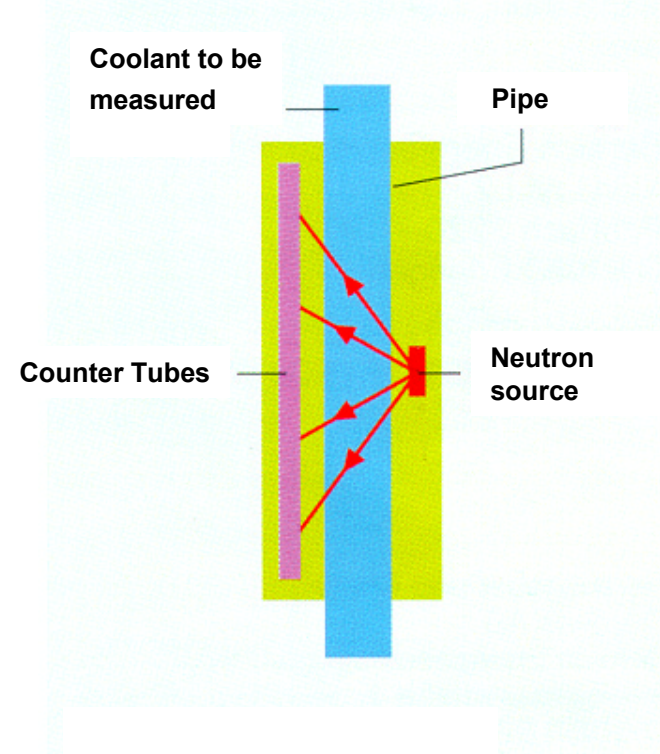
## Objectives

- 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:**

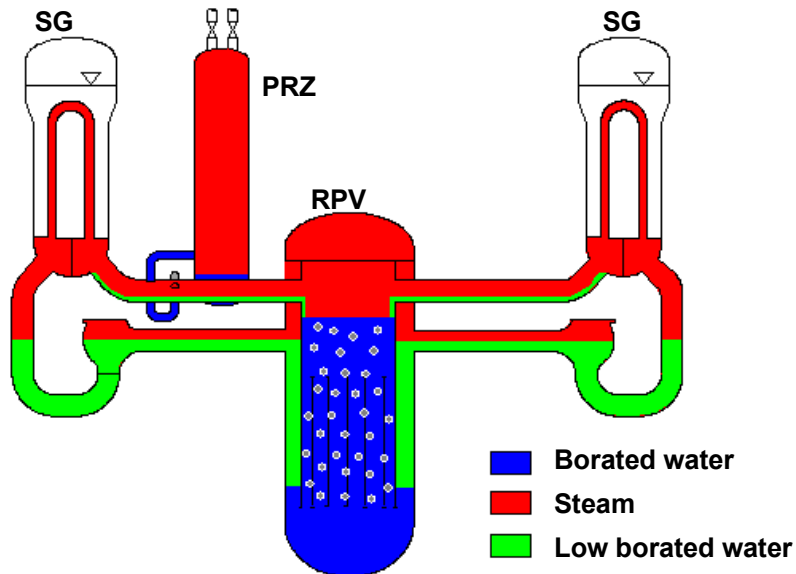
- ***Low borated water entering the core can lead to local recriticality and thereby to a power excursion***
- ***A necessary condition for this to happen is the formation of low borated water slugs in the primary and their transport to the core without sufficient mixing***
- ***Formation of low borated 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)

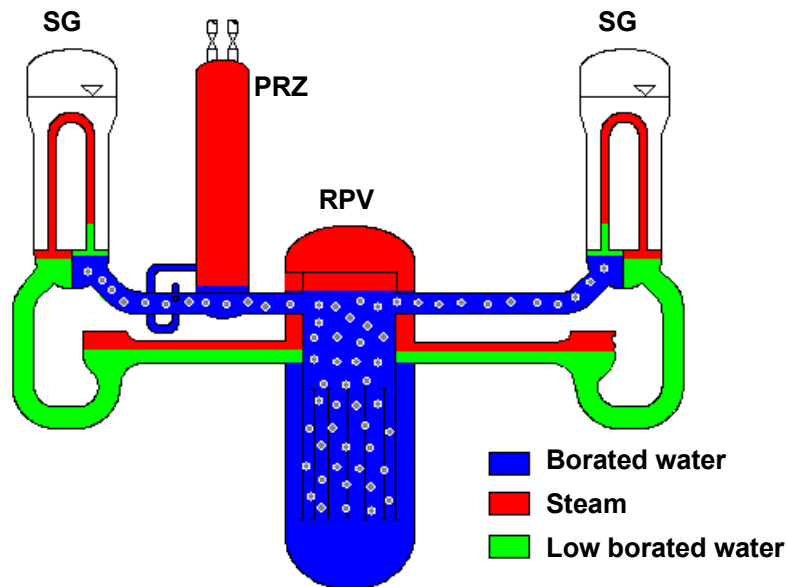


Initial conditions

- Break in the hot leg of the pressurizer loop (40cm<sup>2</sup>)
- 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***

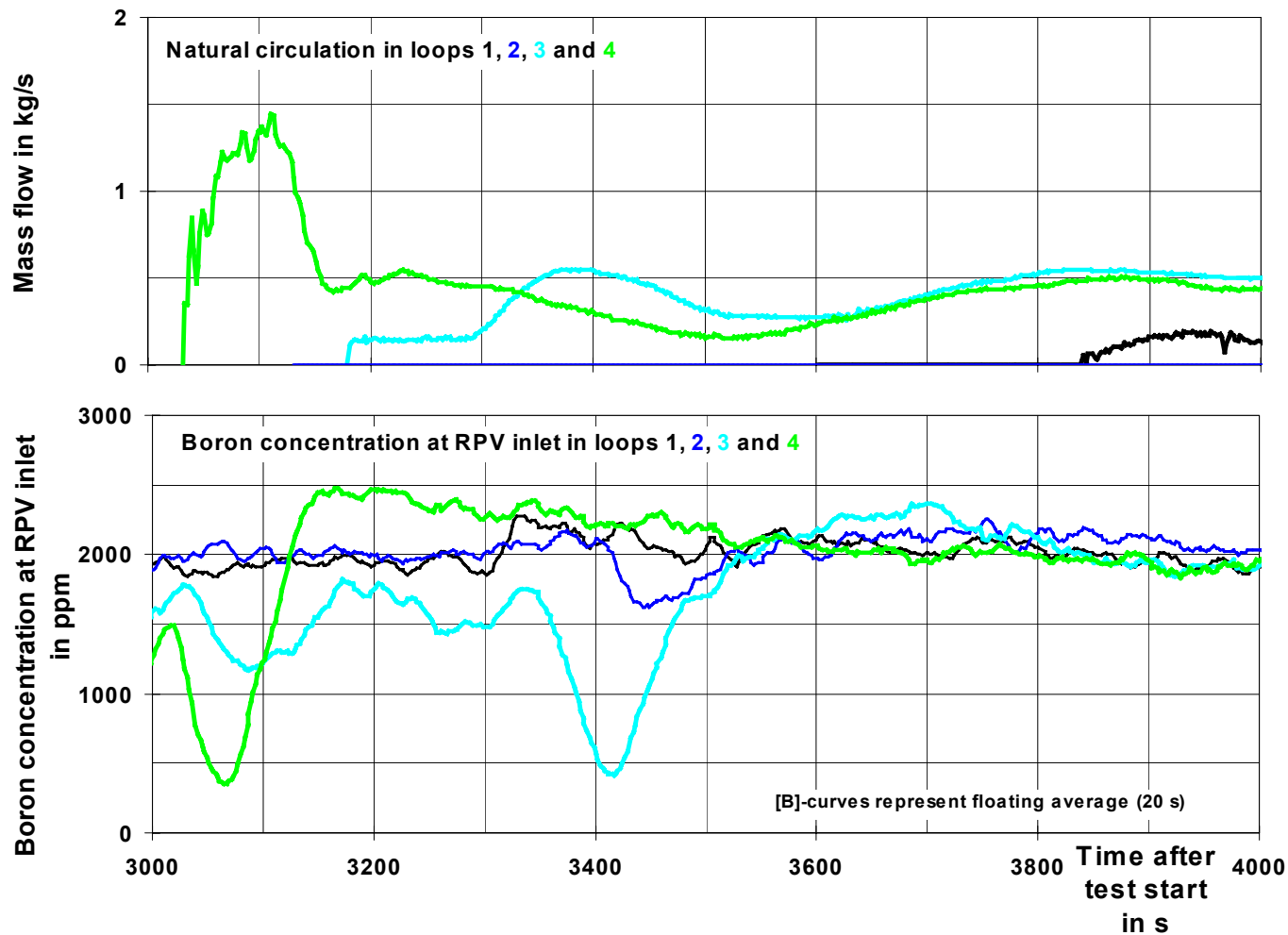
**Maximum amount of unborated water: cold leg injection (E2.2)**



**Initial conditions**

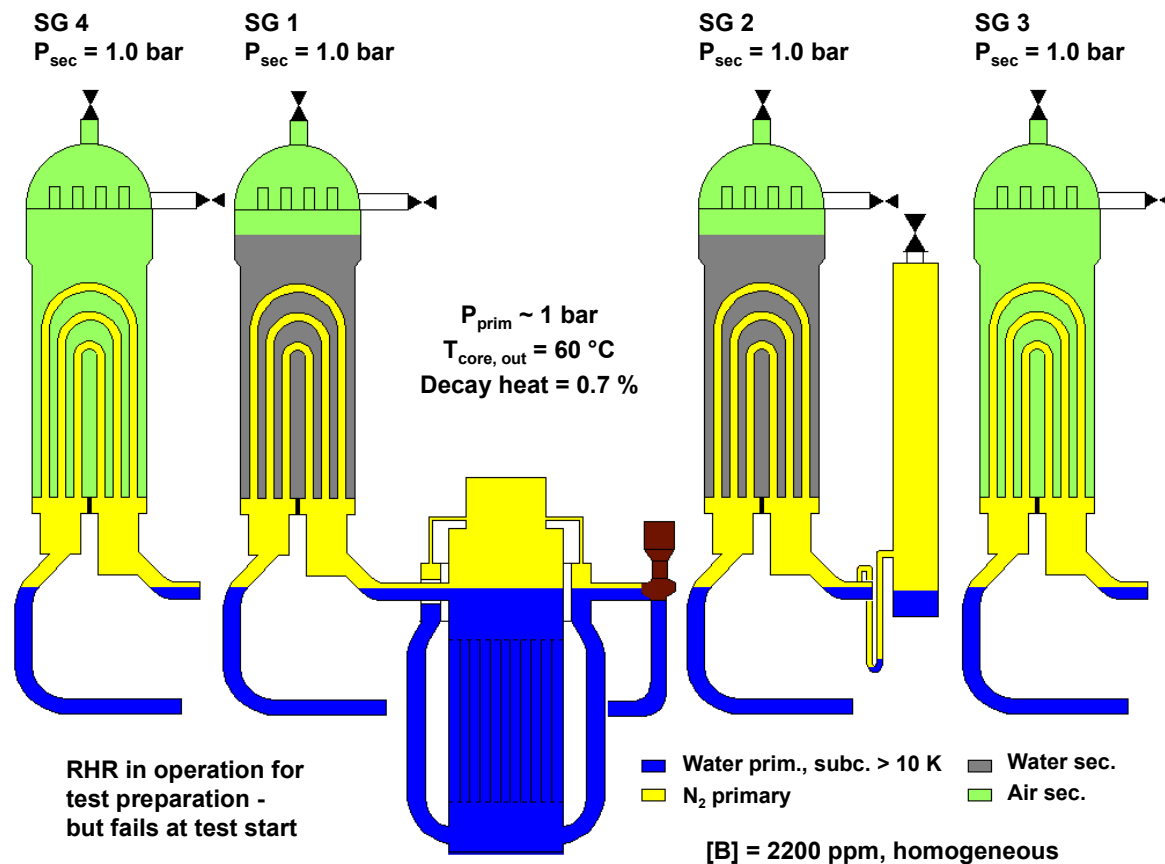
- ***Break in the cold leg of loop 1 (32cm<sup>2</sup>)***
- ***100 K/h cooldown of the SG-secondaries***
- ***2 out of 4 HP-SIPs (cold leg, 1 in break loop)***
- ***Continuous boron concentration measurement(COMBO) at the RPV inlet in all 4 loops***

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



# PKL III E3.1: Loss of RHRS

## Initial Conditions



## Scenario

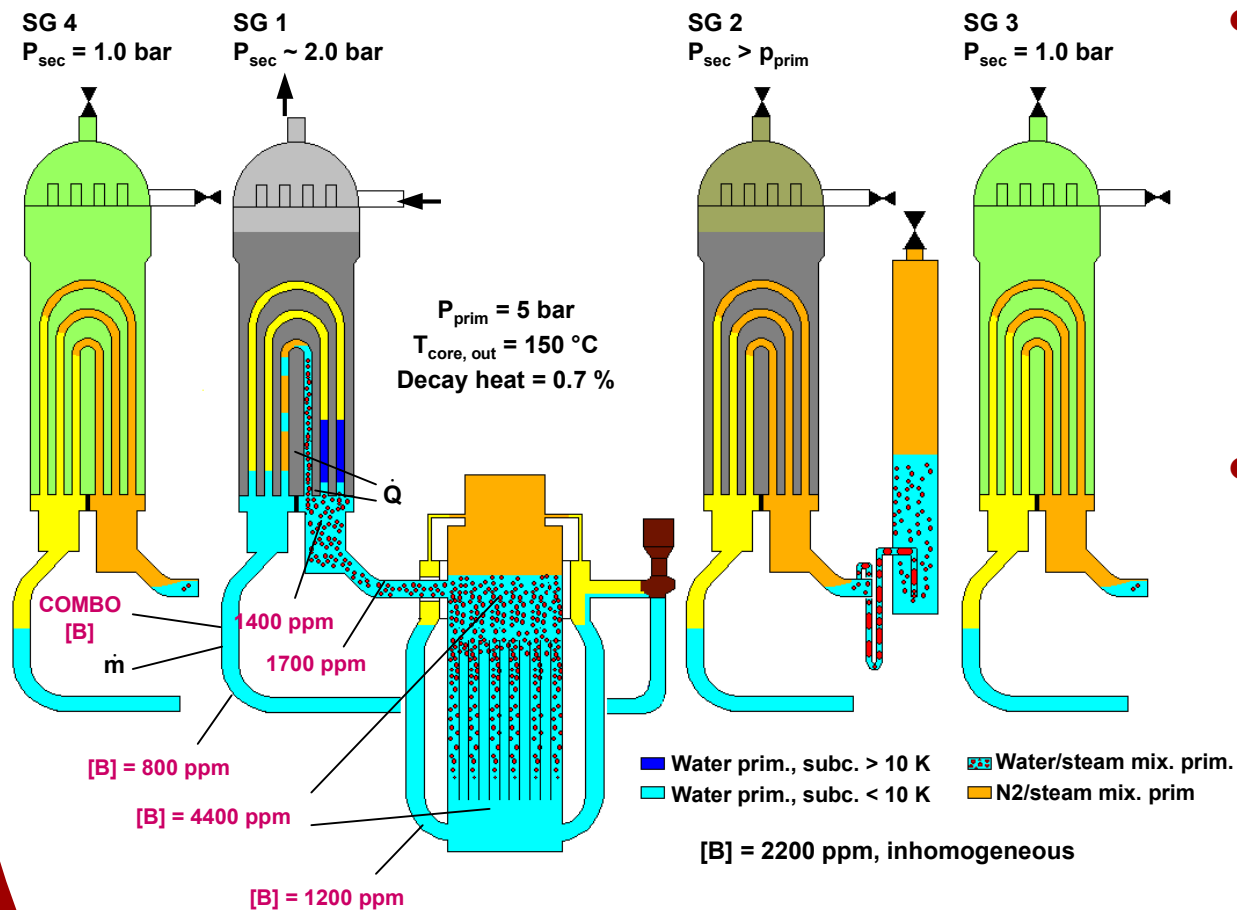
- Total failure of RHRS when the reactor is shut down, e.g. for refuelling (primary system still closed)
- 2 SGs filled with water, one of both (SG 1) ready for operation

## Objectives

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

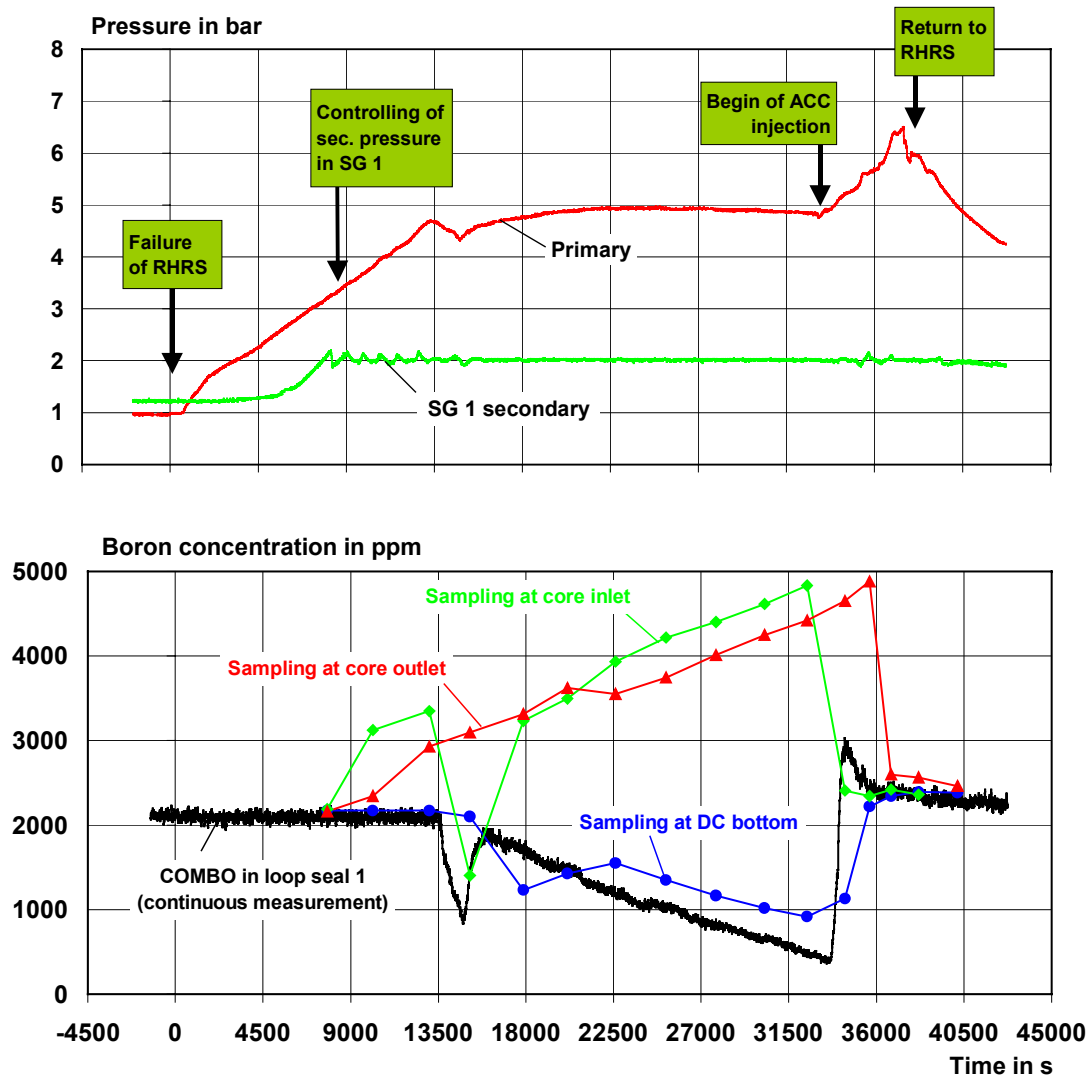
# PKL III E3.1: Loss of RHRS

## 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*
  - *Intermittent 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**)*