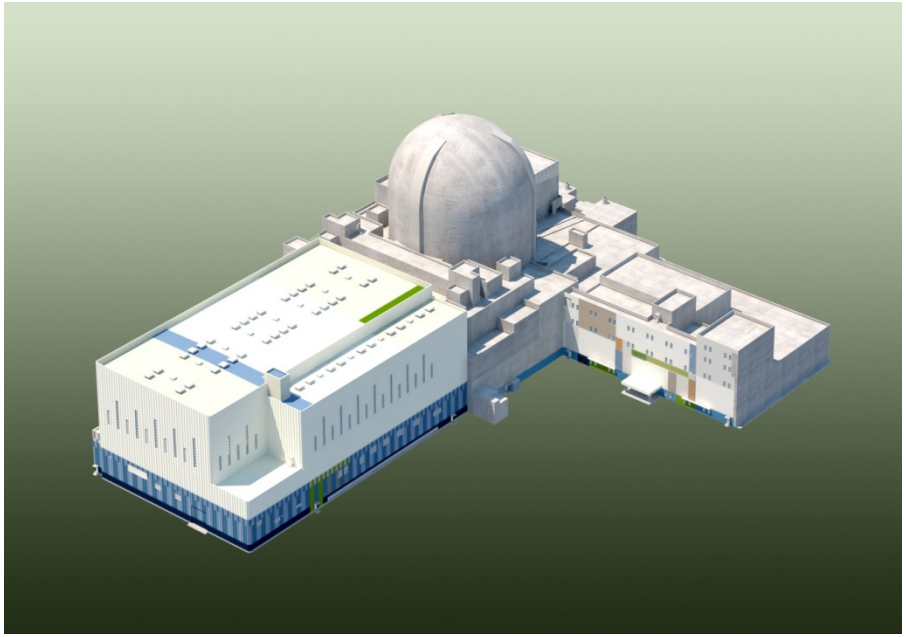
Non-Proprietary

Boron Dilution During Inadvertent Dilution Events



KEPCO/KHNP

April 29, 2015

Public meeting

Contents

- Complete Mixing Assumption
  - The LOFT experiment L6-6
  - Results of the LOFT experiment L6-6
  - Core fluid velocity of APR1400 during SCS operation
- Design Margin of the System
  - Acceptance criteria in SRP
  - BDAS setpoint
- Conclusions

- **Complete Mixing Assumption**

Complete Mixing Assumption

- The complete mixing model was used to analyze a BDA during SCS operation based on the LOFT L6-6 experimental results
- The LOFT experiment L6-6
  - ✓ Scale : 1/40 scaled down from the Trojan plant
  - ✓ Purpose : To provide data which can be used to evaluate the conservatism of the method used by PWR vendors to determine the minimum time to reach criticality in an inadvertent boron dilution events
  - ✓ Condition : This experimental conditions were similar to those experienced during a PWR refueling outage where the RCS is drained and the shutdown cooling system is operating

[NRC Fin No. A6048-LOFT Experimental Program]

Complete Mixing Assumption

- **Results of the LOFT experiment L6-6**
  - ✓ **During this experiment, the fluid velocity in the reactor core was approximately 0.066 ft/s (0.02 m/sec) and this fluid velocity ensured that a well-mixed reactor vessel volume was achieved**
  - ✓ **The LOFT experiment results also showed that other volumes, wherein the fluid was moving with very low velocity (intact loop hot leg / surge line / pressurizer), also were mixed**
  - ✓ **The predicted time to criticality using complete mixing model was about 30 percent more conservative than the L6-6 experimental results as due to dilution of stagnant volumes that are conservatively neglected in the complete mixing model**

[NRC Fin No. A6048-LOFT Experimental Program]

Complete Mixing Assumption

- **Core fluid velocity of APR1400 during SCS operation**
  - ✓ **SCS minimum flow rate : 4,150 gpm (Tech. Spec. 3.9.4.1.)**
  - ✓ **Core flow area : 62.7 ft^2 (DCD, Table 4.4-1)**

    Mass flow rate = ρvA

    v(velocity) = [mass flow rate]/ρA

    = [4,150 gpm x 0.1337 ft^3/gal] / 62.7 ft^2 = 0.147 ft/sec (0.045 m/sec)
  - ✓ **Calculated core fluid velocity of APR1400 is about 0.045 m/sec**

    → More than two times higher than the minimum fluid velocity value support the complete mixing assumption

- **Design Margin of the System**

Design Margin of the System

- **Acceptance Criteria in SRP**
  - ✓ **Mode 1 ~ 5 : 15 minutes of operator action time**
  - ✓ **Mode 6 : 30 minutes of operator action time**
  - ✓ **But we applied 30 minutes of operator action time for all Modes**

- **BDAS setpoint**
  - ✓ **Calculated minimum setpoint of the BDAS is 2.67**
  - ✓ **We reduced 25 percent of the setpoint from this calculated value to accommodate a non-linear response of the ex-core detector (2.00)**
  - ✓ **Final setpoint of the BDAS is 1.80 to reserve the proper margin and compensate the impact due to the reload core design change**

- **Conclusions**

Conclusions

- Complete mixing assumption is valid to apply during the shutdown cooling system operation
- APR1400 has a appropriate design margin for a boron dilution event

Thank you for your attention.

Acronyms

APR – Advanced Power Reactor
BDA – Boron Dilution Accident
BDAS – Boron Dilution Alarm System
LOFT – Loss of Fluid Test
RCP – Reactor Coolant Pump
SCS – Shutdown Cooling System
SRP – Standard Review Plan