RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**511-8668**
SRP Section:	**15.04.06 – Inadvertent Decrease in Boron Concentration in the Reactor Coolant (PWR)**
Application Section:	**15.04.06**
Date of RAI Issue:	**08/01/2016**

Question No. 15.04.06-8

10 CFR Part 50 Appendix A, GDC 10 requires that the reactor core and associated coolant, control and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences. The inadvertent reactor coolant system (RCS) boron dilution event is classified as anticipated operational occurrence per Standard Review Plan (SRP) 15.4.6. SRP 15.4.6 states the minimum departure from nucleate boiling ratio (DNBR) should be above the safety analysis DNBR limit for at power operations.

In response to RAI 8221, Question 15.4.6-5, the applicant stated that the reactivity insertion rate due to an at power boron dilution event is bounded by the control element assembly (CEA) withdrawal analyses of DCD Sections 15.4.1 and 15.4.2. The staff notes that the CEA withdrawal analyses do not violate the minimum DNBR limit as the variable overpower trip occurs limiting the power excursion. It is unclear to the staff that a slow reactivity insertion transient such as a boron dilution at power would be protected by the variable overpower trip. Therefore, please describe and update DCD section 15.4.6 with the reactor trip that would occur for an at power boron dilution event, and the technical basis why that reactor trip would prevent violating the minimum DNBR.

Response

During a slow power increase transient such as a boron dilution at power, as the NRC staff noted in the question, the variable over power trip (VOPT) would not be appropriate to prevent the DNB violation. For this reason, APR1400 has a digital reactor trips: core protection calculation system (CPCS) DNBR trip or other CPCS auxiliary trip, such as cold leg temperature range trip and pressure range trip. The CPCS variable overpower trip can occur during fast power increasing transients and the CPCS DNBR trip or other CPCS auxiliary trip (cold leg temperature range trip or primary pressure range trip) can occur during slow power increasing transients. Figures 1 and 2, which were presented in RAI 8434, Question 15.04-02-1, show that the CPCS DNBR trip and other CPCS auxiliary trip can protect the DNBR limit for the slow reactivity increase transient and the VOPT can for the fast reactivity insertion rate case. The maximum reactivity insertion rate from an at power boron dilution event is less than 0.8 pcm/sec. Therefore the CPCS DNBR trip or the CPCS auxiliary trip can protect the DNBR limit for the boron dilution event at power and the minimum DNBR value is bounded by the control element assembly (CEA) rod withdrawal event.

The CPCS calculates a DNBR in the core not only the steady state but also the transient state. During transient situations, the inherent time response for the process instrumentation in the CPCS reactor protection system (RPS), and nuclear steam supply system (NSSS) to changes in the measured parameters will cause the inputs to the CPCS to lag, this is a condition that can actually exist in the plant. In some transient situations, this lag of CPC inputs could lead to the calculation of non-conservative values for DNBR. Therefore, CPC dynamic compensation algorithms exist to assure that during transient situations the CPCS will prevent the violation of the SAFDL on DNBR. This dynamic adjustment is accomplished by using static offset and digital filters to compensate for either the measured parameter directly (as is done for cold leg temperature and pressurizer pressure) or the calculated parameter (as is done for the thermal power, neutron flux power). The CPCS constants for the dynamic compensation algorithm and penalty values are determined at the final CPCS design stage for a constructed plant. The detailed technical basis for the dynamic CPCS DNBR compensation is presented in RAI 8434, Question 15.04.02-1.

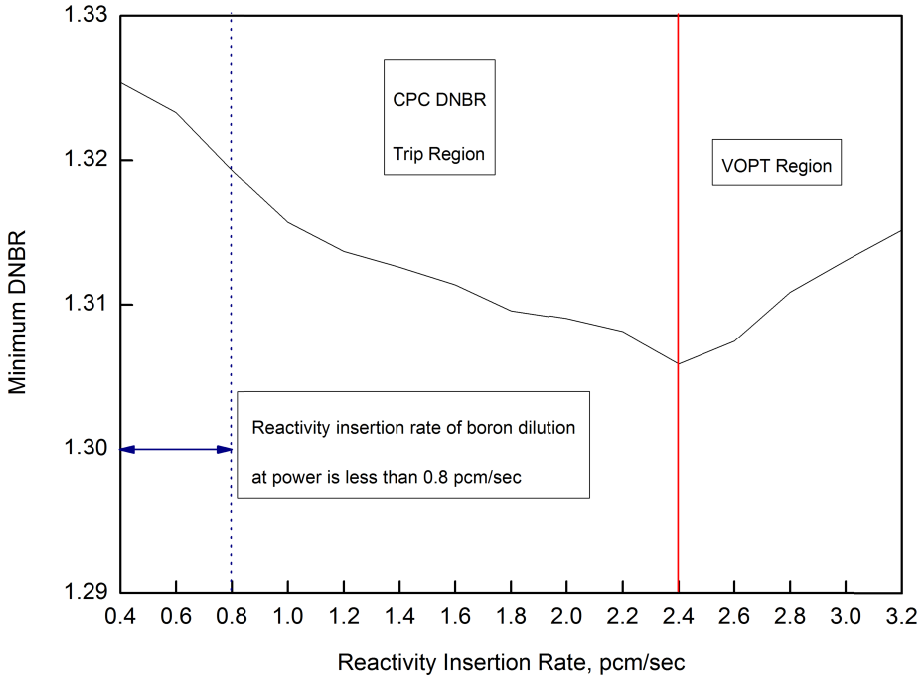

Figure 1. Minimum DNBR vs. Reactivity Insertion Rate
(Bank CEA withdrawal transient at 102% Power)

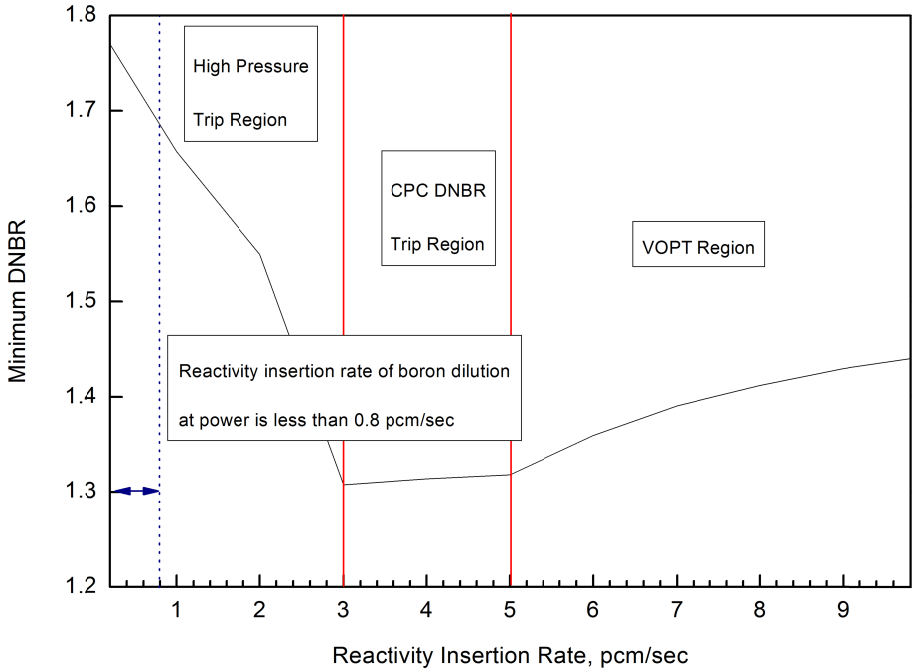

Figure 2. Minimum DNBR vs. Reactivity Insertion Rate
(Bank CEA withdrawal transient at 50% power)

Impact on DCD

There is no impact on DCD.

Impact on PRA

There is no impact on PRA.

Impact on Technical Specifications

There is no impact on Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.