REVISED 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.:	**346-8434**
SRP Section:	**15.04.02 – Uncontrolled Control Rod Assembly Withdrawal at Power**
Application Section:	**15.04.02**
Date of RAI Issue:	**12/22/2015**

Question No. 15.04.02-1

REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 10 requires the core and associated coolant, control, and protection systems to be designed with appropriate margin to assure that specified acceptable fuel design limits (SAFDLs) are not exceeded during any condition of normal operation, including the effects or anticipated operational occurrences (AOOs). GDC 20 requires, in part, that the protection system be designed to initiate automatically the operation of appropriate systems to ensure that SAFDLs are not exceeded as a result of AOOs. GDC 25 requires the protection system to be designed to ensure that SAFDLs are not exceeded for any single malfunction of the reactivity control systems.

Section 15.4.2 of NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Subsection III, “Review Procedures,” states the following under Item 1: “*the review considers the entire power range from low to full power and the allowed extreme range of reactor conditions during the operating (fuel) cycle, including rod configurations, power distribution, and associated reactivity feedback components… The review considers a full range of rod or bank withdrawals, up to maximum rod or bank worths and rates of reactivity addition.”* In addition, Item 3 states that “*the reviewer ascertains that a full range of AOO conditions are analyzed…*” and gives a list of parameter ranges to consider, including: (a) initial power levels from low to full power, and (b) reactivity insertion rates from very low to maximum possible, including allowances for uncertainties. The reviewer is guided to verify that these ranges of conditions have been examined, and that the most limiting case has been analyzed.

ISSUE

In DCD Section 15.4.2.3.2, the applicant indicates that the initial power level is assumed to be 102% of the core thermal power. The applicant also states that beginning power levels from low to full power are analyzed in the design stage for the core operating limit supervisory system

(COLSS) and the core protection calculator system (CPCS). Such analyses would partially address the requirement that the analysis include the entire power range from low to full power. The applicant's statement implies that such analyses have been completed, though a review of available documentation has not located sufficient information about the results of the power study. In particular, documentation addressing the results for rod withdrawal scenarios beginning at a range of power levels has not been provided.

Section 15.4.2.3.2 of the DCD also states that the rod withdrawal rate was selected based on the calculated control element assembly (CEA) worth and associated uncertainties to produce the worst transient. A calculated differential CEA worth and the maximum CEA withdrawal rate were used to compute the maximum expected reactivity insertion rate. The maximum rate was used in the analysis. The application also states that "*reactivity insertion rates from very low to maximum possible for the control system, including allowance for uncertainties, are analyzed in COLSS/CPCS design stage*". Again, review of the available supporting documentation has not located any discussion of the analysis or results that address the requirement that a range of reactivity worths and insertion rates be evaluated for this scenario. The peak linear heat generation rate (PLHGR) for this event is 19.27 kW/ft and the AOO limit is 20 kW/ft. Thus, the PLHGR is close enough to the limit that further review is needed to verify that the limiting event is being analyzed. Additional documentation is needed for showing acceptable performance of the system in response to rod withdrawals using a range of reactivity insertion rates.

INFORMATION NEEDED

Please provide documentation supporting the assertion that ranges of power levels and reactivity insertion rates were examined for DCD Section 15.4.2, "Uncontrolled Control Element Assembly Withdrawal at Power." Please include results from any sensitivity analyses that were performed.

As appropriate, the applicant should update the DCD and referenced technical reports.

Response – (Rev. 1)

The results of the CEA bank withdrawal at power provided in DCD Section 15.4.2 are the limiting transient for local power density (LPD). The peak linear heat generation rate (PLHGR) for this event, 19.27 kW/ft, is calculated by assuming a conservative initial condition of the linear heat generation rate (LHGR), 14.5 kW/ft; this value is bigger than the current LCO limiting value, 13.6 kW/ft.

A full range of initial power levels and reactivity insertion rates for the CEA bank withdrawal are covered by the on-line reactor protection system. The core protection calculator system (CPCS) is a safety grade system, which is designed to provide departure from nucleate boiling ratio (DNBR) and local power density (LPD) protection for anticipated operational occurrences (AOOs). Therefore the CEA bank withdrawal at low power level can be protected by the CPCS as described in the Document APR1400-F-C-NR-14003-P, Rev.0, "Functional Design Requirements for a Core Protection Calculator System for APR1400," which has been provided to the NRC. The uncontrolled sequential withdrawal of CEA groups from critical conditions is one of the CPCS design basis events (Refer to Subsection 2.2.B.1 of APR1400-F-C-NR-14003-P, Rev.0).

During the steady state operation, the sensors monitored by the CPC give accurate measurements of the actual core conditions which exist in the plant. Using these inputs, the CPC calculates a conservative value for minimum DNBR and maximum LPD existing in the core.

During transient situations, however, the inherent time response for the process instrumentation in the CPC system, 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 conditions, which 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 and LPD. It is the function of the CPC dynamic compensation algorithms to assure that, during transient situations, the CPC system will prevent the violation of the SAFDL on DNBR and LPD. 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 calculated parameter (as is done for the thermal power, neutron flux power, and LPD calculations).

The CPCS constants for the dynamic compensation algorithm and penalty values are determined at the final CPCS design stage for a constructed plant. Therefore, typical analysis is performed to show that the CPC can prevent the violation of the SAFDL on DNB and LPD during the CEA bank withdrawal at 102% and 50% power level with various reactivity insertion rates.

As shown in Figure 1 and Figure 2, the compensated heat flux, which is used for the DNBR calculation, is higher than the real heat flux. Therefore, the DNBR calculated by CPC is more conservative than the actual DNBR value.

Figure 3 and Figure 4 show the minimum DNBR with a variety of reactivity insertion rates for the CEA bank withdrawal at 102% and 50% power level. Fast power increasing transients are protected by CPCS variable overpower trip and slow power increasing transients are protected by CPCS DNBR trip or other CPCS auxiliary trip.

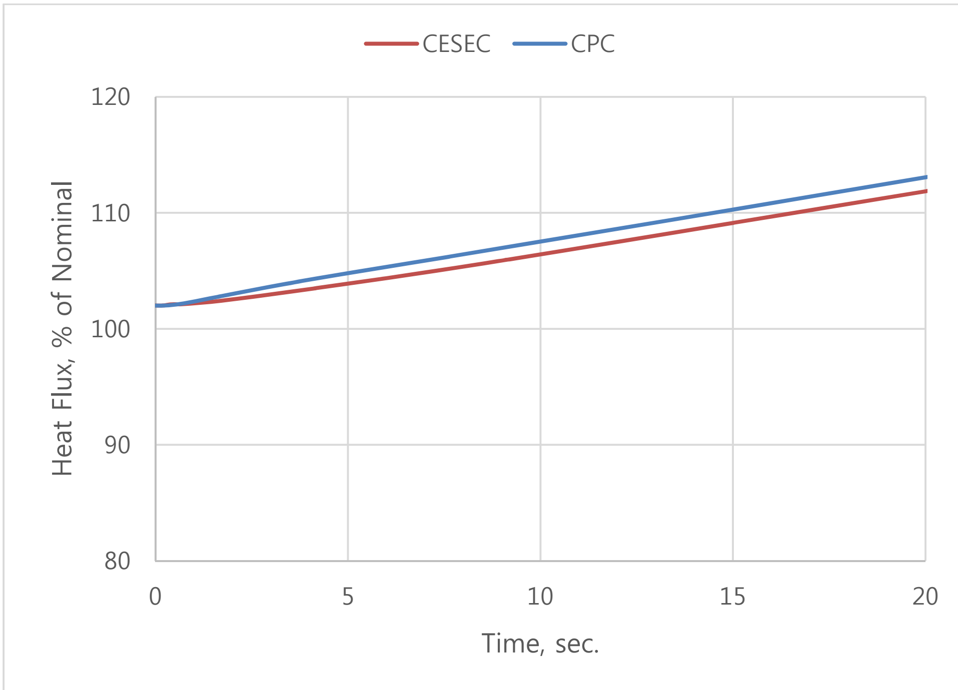

Figure 1. Heat flux vs. Time (102% power level, 3.15 pcm/sec)

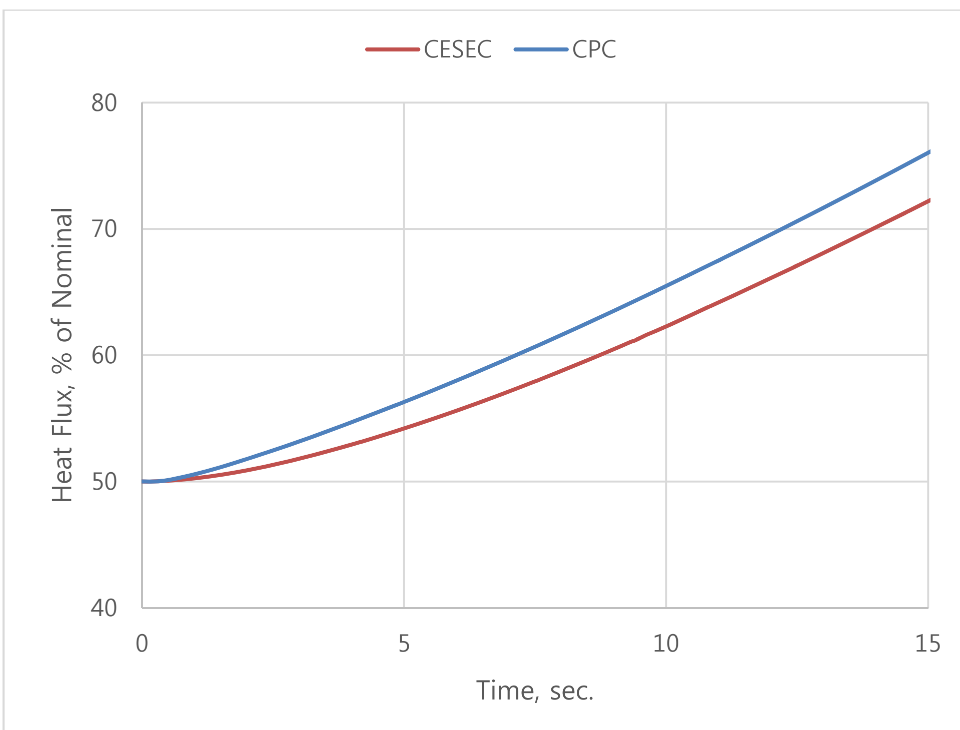

Figure 2. Heat flux vs. Time (50% power level, 10.0 pcm/sec)

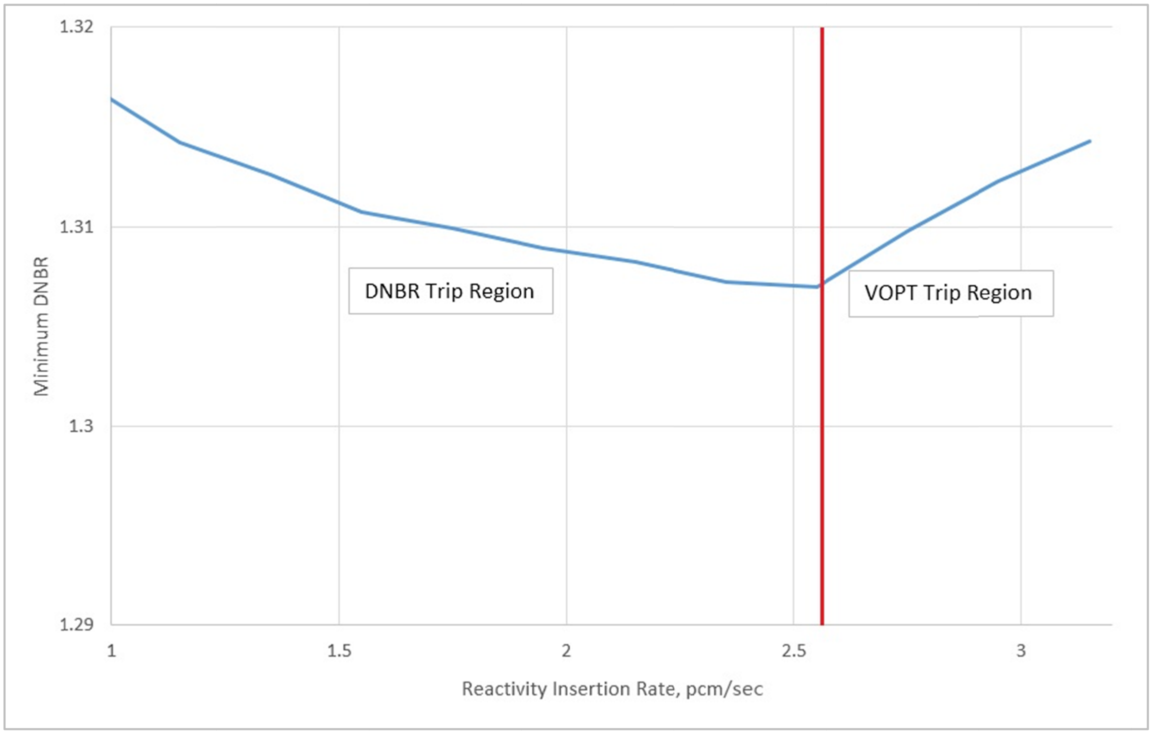

Figure 3. Minimum DNBR vs. Reactivity insertion rate (102% Power)

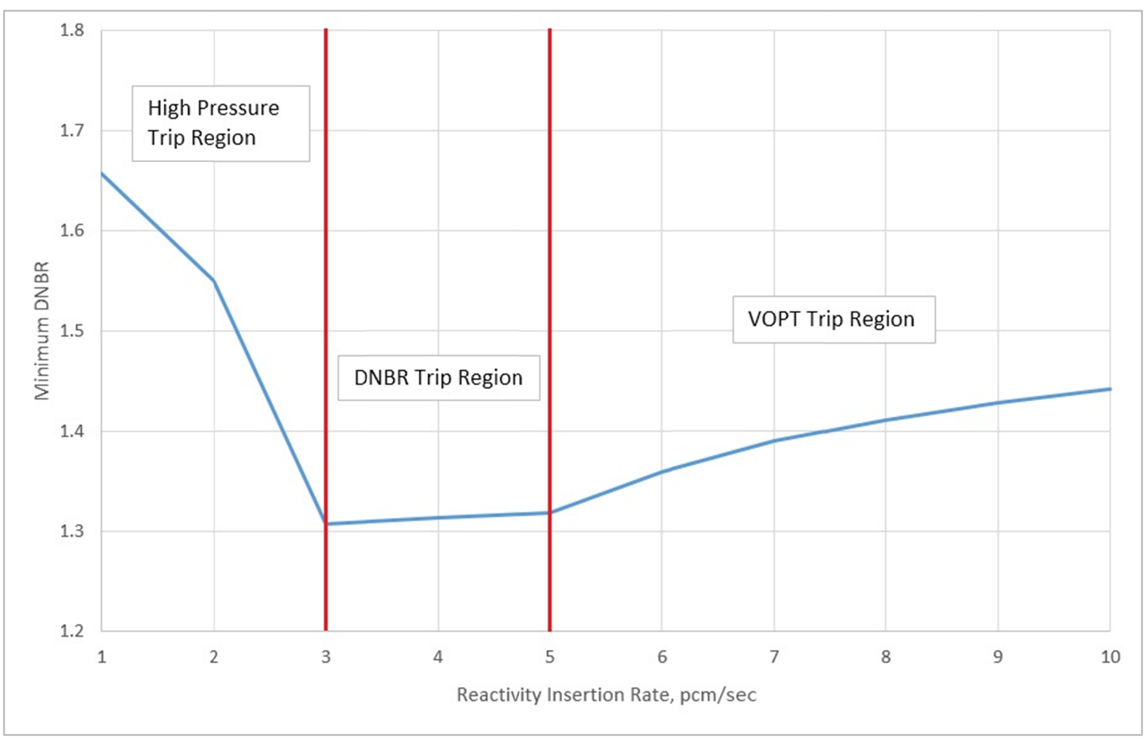

Figure 4. Minimum DNBR vs. Reactivity insertion rate (50% Power)

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 Report

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