KHNPDCDRAIsPEm Resource

From: Ciocco, Jeff
Sent: Tuesday, December 22, 2015 8:21 AM
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Cc: Carlson, Donald; McKirgan, John; Steckel, James; Lee, Samuel
Subject: APR1400 Design Certification Application RAI 347-8435 (15.04.03 - Control Rod Misoperation (System Malfunction or Operator Error))
Attachments: APR1400 DC RAI 347 SRSB 8435.pdf

KHNP,

The attachment contains the subject request for additional information (RAI). This RAI was sent to you in draft form. Your licensing review schedule assumes technically correct and complete responses within 30 days of receipt of RAIs.

Please submit your RAI response to the NRC Document Control Desk.

Thank you,

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United States Nuclear Regulatory Commission
Protecting People and the Environment

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REQUEST FOR ADDITIONAL INFORMATION 347-8435

Issue Date: 12/22/2015
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 15.04.03 - Control Rod Misoperation (System Malfunction or Operator Error)
Application Section:

QUESTIONS

15.04.03-1

Question 15.4-2: Justification that the analyzed CEA drop is limiting for DCD Section 15.4.3

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 15.4.3 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: "*For each failure event analyzed, the cases which result in a limiting fuel rod condition should be presented. Initial conditions and parameter values selected for these cases should be justified with a sensitivity analysis or discussion. Conditions of first-order importance for any time in cycle are initial power level and distribution, initial rod configuration, reactivity addition rate, moderator temperature, fuel temperature, and void reactivity coefficients.*"

ISSUE

The applicant presents a four-finger single control element assembly (CEA) drop as the limiting event analyzed in DCD Section 15.4.3. As analyzed, this event does not cause a reactor trip but results in an approach to the specified acceptable fuel design limit (SAFDL) on minimum departure from nucleate boiling ratio (DNBR). DCD Section 4.3.2.5 indicates that the full-strength CEA drop incident is analyzed by selecting the dropped CEA that maximizes the increase in the radial peaking factor and that a conservatively small negative reactivity insertion is used in the event analysis. However the application does not provide supporting information such as an examination of the range of CEA worths and locations. It is therefore not clear that a CEA drop into both a high flux and low flux region has been considered or that cases with a part-strength CEA drop have been examined.

Furthermore, the maximum radial peak distortion following a four-finger CEA drop is assumed to be 1.205. However, the application does not describe the basis for this factor and the uncertainties that are covered by it. According to the audited calculation note related to this event, APR1400-F-A-TM-12004-P, Rev. 0, "CEA Drop Analysis for US-APR1400," dated August 2012, the distortion factor of 1.205 is a multiplier on the initial integrated radial peaking factor. DCD Table 15.4.3-2 lists the integrated radial peaking factor as 1.37. According to DCD Table

4.3-10, this roughly corresponds to a “P” (part-strength) rodded core configuration at end-of-cycle (EOC) conditions. Consequently, the integrated radial peaking factor following the CEA drop is 1.205*1.37, which is 1.644. However, absent necessary supporting information, the staff can neither confirm which rodded configuration yields the largest peaking factor nor assess the basis for the assumed maximum radial peak distortion factor of 1.205.

In addition, the audited calculation note indicates that, as of August 2012, the 12-finger CEA drop had not been evaluated but will be in future analyses for the core operating limiting supervisory system (COLSS) and the core protection calculator system (CPCS). The calculation note also states that, if a 12-finger CEA drops, the CPCS will appropriately generate a trip if it is necessary because the CPCS conservatively calculates DNBR every 0.05 seconds. The applicant has nevertheless provided no information on its analyses for 12-finger CEA drop events. Absent such information, the staff can neither assess the applicant’s analyses for a range of 12-finger CEA drop events nor verify their implications, if any, for determining the limiting CEA drop event.

INFORMATION NEEDED

Please provide justification that the four-finger single CEA drop is the limiting event for DCD Section 15.4.3. A summary of analysis results using different rodded core configurations, dropped rod types and locations, and different cycle conditions would assist the reviewer in confirming that the event analyzed is the limiting event. Supporting information should include the basis for the maximum radial peak distortion factor of 1.205 as well as a summary of analyses performed for 12-finger CEA drop events.

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

15.04.03-2

Question 15.4-3: Three-dimensional effects in the asymmetric CEA drop for DCD Section 15.4.3

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 15.4.3 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 2: “*For each event, the analytical methods used by the applicant are reviewed… In either case, the reviewer should determine whether the applicant's evaluation methods are acceptable.”*

ISSUE

CEA drop events are analyzed by the applicant with the CESEC-III code described in DCD Section 15.0.2.2.1. The CESEC-III model includes a 3D reactivity feedback model, which is important for incorporating local changes in the thermal-hydraulic conditions. However, a point kinetics solver is used to determine the neutronic behavior in the core. Since the single CEA drop produces an asymmetric flux shape, the point kinetics solution will not yield accurate flux shape information for determining the local peaking factor. The applicant has not addressed how these spatial core physics phenomena are treated in the analysis. This is important because the calculated minimum departure from nucleate boiling ration (DNBR) is near the limit of 1.29. In addition, xenon redistribution following the CEA drop increases the power distortion over time, as indicated in the audited calculation note related to this event (APR1400-F-A-TM-12004-P, Rev. 0, “CEA Drop Analysis for US-APR1400,” August 2012). How this is accounted for in the methodology is not clear because CESEC-III does not model 3D xenon distributions.

DCD Section 15.0.2.2.1 indicates that a detailed thermal-hydraulic model simulates the mixing in the lower plenum from asymmetric transients. This, in combination with the use of the CETOP code for computing three-dimensional fluid conditions in the core, should give a reasonable estimate of the local flow conditions and thus the thermal margin on DNBR. However, since mixing in the lower plenum will have an impact on local core physics parameters, more detail is needed for the conditions in the lower plenum. Since the CEA drop is an asymmetric event, using point kinetics may not yield sufficient accuracy in the local peaking factor used to determine the local heat flux, and subsequently, the minimum DNBR. In addition, effects of flow mixing in the lower plenum and in the core may have an impact on local thermal-hydraulic and core physics conditions including the local peaking factor.

INFORMATION NEEDED

Please provide a discussion of how the three-dimensional effects, including spatial xenon redistribution over time, are taken into account in analyzing asymmetric CEA drops for DCD Section 15.4.3. Please include a discussion of any uncertainties that are incorporated into the maximum radial peak distortion factor.

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

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