KHNPDCDRAIsPEm Resource

From: Ciocco, Jeff
Sent: Tuesday, October 27, 2015 2:43 PM
To: apr1400rai@khnp.co.kr; KHNPDCDRAIsPEm Resource; Harry (Hyun Seung) Chang; Andy Jiyong Oh; James Ross
Cc: Van Wert, Christopher; McKirgan, John; Olson, Bruce; Lee, Samuel
Subject: RE: APR1400 Design Certification Application RAI 275-8294 (04.02 - Fuel System Design)
Attachments: APR1400 DC RAI 275 SRSB 8294.pdf

With the attachment.

Thanks,

From: Ciocco, Jeff
Sent: Tuesday, October 27, 2015 12:40 PM
To: apr1400rai@khnp.co.kr; KHNPDCDRAIsPEm Resource <KHNPDCDRAIsPEm.Resource@nrc.gov>; Harry (Hyun Seung) Chang <hyunseung.chang@gmail.com>; Andy Jiyong Oh <jiyong.oh5@gmail.com>; James Ross <james.ross@aecom.com>
Cc: Van Wert, Christopher <Christopher.VanWert@nrc.gov>; McKirgan, John <John.McKirgan@nrc.gov>; Olson, Bruce <Bruce.Olson@nrc.gov>; Lee, Samuel <Samuel.Lee@nrc.gov>
Subject: APR1400 Design Certification Application RAI 275-8294 (04.02 - Fuel System Design)

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. However, KHNP requests, and we grant, 60 days to respond to this RAI. We may adjust the schedule accordingly.

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

Thank you,

Jeff Ciocco
New Nuclear Reactor Licensing
301.415.6391
jeff.ciocco@nrc.gov

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

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Subject: RE: APR1400 Design Certification Application RAI 275-8294 (04.02 - Fuel System Design)
Sent Date: 10/27/2015 2:42:54 PM
Received Date: 10/27/2015 2:43:03 PM
From: Ciocco, Jeff

Created By: Jeff.Ciocco@nrc.gov

Recipients:
"Van Wert, Christopher" <Christopher.VanWert@nrc.gov>
Tracking Status: None
"McKirgan, John" <John.McKirgan@nrc.gov>
Tracking Status: None
"Olson, Bruce" <Bruce.Olson@nrc.gov>
Tracking Status: None
"Lee, Samuel" <Samuel.Lee@nrc.gov>
Tracking Status: None
"apr1400rai@khnp.co.kr" <apr1400rai@khnp.co.kr>
Tracking Status: None
"KHNPDCDRAIsPEm Resource" <KHNPDCDRAIsPEm.Resource@nrc.gov>
Tracking Status: None
"Harry (Hyun Seung) Chang" <hyunseung.chang@gmail.com>
Tracking Status: None
"Andy Jiyong Oh" <jiyong.oh5@gmail.com>
Tracking Status: None
"James Ross" <james.ross@aecom.com>
Tracking Status: None

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REQUEST FOR ADDITIONAL INFORMATION 275-8294

Issue Date: 10/27/2015
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 04.02 - Fuel System Design
Application Section:

QUESTIONS

04.02-1

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 (SAFDLs) are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences (AOOs). SRP Section 4.2(II)(4) provides review guidance regarding postirradiation surveillance programs. In particular, it states the for fuel designs similar to that in other operating plants, a minimum acceptable program should include a qualitative visual examination of some discharged fuel assemblies from each refueling in order to identify gross problems of structural integrity, fuel rod failure, rod bowing, dimension changes, or crud deposition. It further states that a continuing fuel surveillance effort should exist for a given type, make, or class of fuel that can be suitably referenced by all plants using a similar fuel. In the absence of such a generic program, a more detailed plant-specific program is expected.

The APR1400 DCD section 4.2.4.7 discusses an in-service surveillance program, but it appears to be based solely on the results of a previously completed program for an operating plant in Korea.

Staff requests the applicant provide details of the planned cycle by cycle surveillance inspection program which will be used to confirm fuel performance within the bounds of the safety analysis.

04.02-2

GDC 2 requires that SSCs important to safety are designed to withstand the effects of earthquakes without the loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) the severity of the historical reports, with sufficient margin to cover the limited accuracy, quantity, and time period for the accumulated data, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. SRP Section 4.2 Appendix A (II)(5) provides review guidance regarding the combination of loads in order to meet GDC 2.

Technical report APR1400-Z-M-NR-14010-P analyzes SSE, pipe rupture, and IRWST discharge load cases. Section 6.2.6 discusses evaluation results based on a combination of the loads; however, it is unclear how the loads were combined. Additionally, Section 6.2.6 points to Table 6-2, which does not appear in the technical report.

Staff request the applicant clarify the methodology used to combine the loads, and update the technical report as necessary, including the addition of Table 6-2.

04.02-3

GDC 2 requires that SSCs important to safety are designed to withstand the effects of earthquakes without the loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) the severity of the historical reports, with sufficient margin to cover the limited accuracy, quantity, and time period for the accumulated data, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. SRP Section 4.2 Appendix A Section (II)(1) provides guidance regarding the review of input load analyses. It specifically addresses the situation in which earthquake loads are large enough to produce a nonlinear fuel assembly response.

Figure A.2-6 of APR1400-Z-M-NR-14010-P demonstrates that the PLUS7 fuel assembly design exhibits nonlinear behavior, with a natural frequency that varies with vibrational amplitude. This has caused the staff to question the adequacy of the linear lateral vibrational model used in the analysis to model fuel assembly behavior.

Staff requests the applicant provide justification for the use of a linear fuel assembly model to represent the PLUS7 fuel assemblies and update the technical report, if necessary.

04.02-4

GDC 2 requires that SSCs important to safety are designed to withstand the effects of earthquakes without the loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) the severity of the historical reports, with sufficient margin to cover the limited accuracy, quantity, and time period for the accumulated data, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. SRP Section 4.2 Appendix A Section (III)(1)-(2) provides review guidance regarding determination of strength for various fuel assembly components.

Section 6.2 of APR1400-Z-M-NR-14010-P states that the principle of the stress analysis methodology is that there is a direct relationship between the deflection shape of the fuel assembly model and the strains in the structure. The staff is concerned because this is not necessarily true because the linear model used in the methodology offers only an approximation of the fuel bundle deflection shape.

Staff requests the applicant justify the use of a linear method to calculate the stresses on fuel assembly components and update the technical report, if necessary.

04.02-5

GDC 2 requires that SSCs important to safety are designed to withstand the effects of earthquakes without the loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) the severity of the historical reports, with sufficient margin to cover the limited accuracy, quantity, and time period for the accumulated data, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. SRP Section 4.2 Appendix A Section (II)(1) provides review guidance stating that the numerical solution techniques used in performing structural response analyses should be reviewed for appropriateness.

Appendix A of APR1400-Z-M-NR-14010-P presents the fuel assembly test program which were used to verify the PLUS 7 fuel assembly mechanical characteristics or seismic and pipe rupture analyses. The mid-grid crush test program specifically states that beginning of life (BOL) and end of life (EOL) conditions were modeled, but it is unclear if the other tests considered burnup effects on the tests in order to provide a conservative analysis approach.

Staff requests the applicant clarify burnup ranges investigated in the tests presented in Appendix A of APR1400-Z-M-NR-14010-P. If only one burnup was assumed (e.g. BOL or EOL), provide justification that the appropriate burnup was assumed. Update the technical report, if appropriate.

04.02-6

GDC 2 requires that SSCs important to safety are designed to withstand the effects of earthquakes without the loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) the severity of the historical reports, with sufficient margin to cover the limited accuracy, quantity, and time period for the accumulated data, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. SRP Section 4.2 Appendix A Section (II)(1) provides review guidance stating that the numerical solution techniques used in performing structural response analyses should be reviewed for appropriateness.

Section 5.2.2 and Appendix A.2 of APR1400-Z-M-NR-14010-P presents the vibrational testing and model development. The staff notes that the term “natural frequency” is used here to refer to the fuel assembly’s first lateral bending mode frequency. The linear vibrational model described in the technical report is then tuned to a single natural frequency, while in reality the natural frequency of a fuel assembly varies according to the amplitude of vibration. Although not referenced directly in this section of the technical report, CENPD-178-P Rev. 1 is referenced through the CESHOCK code used in the seismic analysis and it indicates that the natural frequency choice is made: “on a conservative basis for each analysis within the bounds provided by the results from the forced vibration test.” The staff is concerned that the chosen natural frequency might not bound the realistic response to the excitation.

Staff requests the applicant provide a detailed explanation how the natural frequencies of the lateral vibration model were chosen for BOL and EOL conditions and justify the chosen value. Update the technical report, if appropriate.

04.02-7

GDC 2 requires that SSCs important to safety are designed to withstand the effects of earthquakes without the loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) the severity of the historical reports, with sufficient margin to cover the limited accuracy, quantity, and time period for the accumulated data, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. SRP Section 4.2 Appendix A (III)(1) provides guidance regarding determination of grid crushing load.

Appendix A.6 of APR1400-Z-M-NR-14010-P presents the mid crush tests used to determine the grid crush load. The text refers to a Figure A.6-2 which is stated to contain plots of grid impact force as a function of impact velocity. This information is used by the staff to understand the amount of plastic

deformation that would occur in a grid at the crush strength. The staff notes that Figure A.6-2 is missing and is unable to ascertain the severity of plastic deformation that occurs at the grid crush strength.

Staff requests the applicant describe the amount of plastic deformation resulting from loads corresponding to the grid crush strength and compare against the grid dimensional tolerances. If the plastic deformation exceeds the dimensional tolerances, justify the chosen impact model. Update the technical report if necessary to capture these points, and also to include the missing Figure A.6-2.

04.02-8

GDC 2 requires that SSCs important to safety are designed to withstand the effects of earthquakes without the loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) the severity of the historical reports, with sufficient margin to cover the limited accuracy, quantity, and time period for the accumulated data, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. Additionally, GDC 27 requires that the reactivity control systems be designed to have a combined capability, in conjunction with poison addition by the ECCS, of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability SRP Section 4.2 (II)(1)(B)(viii) and Appendix A provides review guidance related to mechanical fracturing based on seismic and LOCA applied loads. It is also stated specifically that control rod insertability must be maintained.

Table 6-1 of technical report APR1400-Z-M-NR-14010-P presents stress intensities and limits for the PLUS7 fuel assembly components. Section 7.3 of the technical report discusses the faulted condition criteria used for calculating the stress limits for components other than the grids. These limits appear to be based on ASME Boiler and Pressure Vessel Code values for service level D. Service level D corresponds to “faulted” conditions, which could affect the ability to insert RCCAs, and therefore challenge GDC 27.

Staff requests the applicant clarify the proposed stress-strain limits and what level of damage could occur to the components based on those limits. If damage could occur to the guide tubes based on the limits, justify the limits via rod insertion tests to demonstrate control rod insertability. Update the technical report, as necessary, to capture these points.


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