KHNPDCDRAIsPEm Resource

From: Ciocco, Jeff
Sent: Friday, August 21, 2015 8:48 AM
To: KHNPDCDRAIsPEm Resource
Subject: FW: APR1400 Design Certification Application RAI 151-8078 (03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components)
Attachments: APR1400 DC RAI 151 MEB 8078.pdf; image001.jpg

From: Ciocco, Jeff
Sent: Monday, August 10, 2015 1:40 PM
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Subject: APR1400 Design Certification Application RAI 151-8078 (03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components)

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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U.S.NRC
United States Nuclear Regulatory Commission
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Hearing Identifier: KHNP_APR1400_DCD_RAI_Public
Email Number: 209

Mail Envelope Properties (7210a32e9dd8412ca557401da7cf02d8)

Subject: FW: APR1400 Design Certification Application RAI 151-8078 (03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components)
Sent Date: 8/21/2015 8:47:55 AM
Received Date: 8/21/2015 8:47:56 AM
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Tracking Status: None

Post Office: HQPWMSMRS08.nrc.gov

Files	**Size**	**Date & Time**
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image001.jpg	5056	

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Priority: Standard
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Sensitivity: Normal
Expiration Date:
Recipients Received:

REQUEST FOR ADDITIONAL INFORMATION 151-8078

Issue Date: 08/10/2015
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components
Application Section: 3.9.2

QUESTIONS

03.09.02-1

The initial test program is implemented to demonstrate that the piping systems, restraints, components, and supports have been designed to withstand flow-induced dynamic loading under the steady-state and operational transient conditions anticipated during service, to confirm that proper allowance for thermal contraction and expansion is provided, and to demonstrate that piping vibrations are within the acceptable level such as those caused by an in-line component trip. The applicant stated in DCD Tier 2 Section 3.9.2.1 that the supports and restraints necessary for operation during the life of the plant are considered to be parts of the piping system. Therefore, to meet the GDC 1, the staff requests the applicant to justify the applicability of the stress limits in the referenced guidance of ASME OM-S/G-1990 during steady state vibration are to be based for the 60-year life.

03.09.02-2

The staff reviewed DCD Tier 2, Sections 3.9.2 and 14.2.12.1, which state that the initial test program (ITP) of piping systems is applicable to the ASME BPV Code Section III, Class 1, 2, and 3 piping systems. The applicant did not, however, identify testing applicable to other piping systems not designed to the ASME BPV Code Section III. Based on SRP Section 3.9.2 Item I.1.D, the staff requests the applicant to provide a list seismic Category I portions of moderate energy piping systems located outside containment and confirm that it is included in the scope of the ITP similar to the ASME BPV Code Section III piping.

03.09.02-3

DCD Tier 2, Section 3.9.2.1 states that when applicable, the initial test program (ITP) includes a list of systems, flow modes, and selected locations for visual inspections and other measurements, as well as the acceptance criteria and possible corrective actions if excessive vibration or indications of thermal motion restraint occur. It further states that the list of snubbers on systems that are subjected to sufficient thermal movements from cold to hot position is provided as part of the ITP to measure snubber travel. The staff reviewed DCD Tier 2, Section 3.9.2.1 and Section 14.2.12.1, but did not find where the applicant identified which specific systems are included in the testing program, and whether, as stated in SRP Section 3.9.2, testing is conducted on all ASME Class 1, 2, and 3 piping systems. The staff requests the applicant to (a) provide a listing of the high- and moderate-energy piping systems inside containment that are covered by the vibration, thermal expansion, and dynamic effects testing program, (b) verify that the systems to be monitored include all ASME Class 1, 2, and 3 piping systems, and (c) provide the list of snubbers on systems that are subjected to sufficient thermal movements from cold to hot position. The DCD should be revised as needed to clarify the scope of the ITP.

03.09.02-4

In review of the DCD Sections 3.9.2 and 14.2, it is not clear whether the vibration, thermal expansion, and dynamic effects testing program simulates actual operating modes. Section 3.9.2 of the SRP states that an acceptable test program to confirm the adequacy of the design should include a list of the flow modes of operation and transients such as pump trips, valve closures, etc., to which the components will be subjected during the test. In consideration of the transients of the reactor coolant system heat-up tests may include start and trip of the reactor coolant pump (RCP), operation of pressure relieving valves, and closure of turbine stop valve. Therefore, the staff requests the applicant to provide a listing of the different flow modes to which the systems will be subjected during the vibration, thermal expansion, and dynamic effects testing program to confirm that the piping systems, restraints, components, and supports have been adequately designed to withstand flow-induced dynamic loadings under the steady-state and operational transient conditions anticipated during service.

REQUEST FOR ADDITIONAL INFORMATION 151-8078

03.09.02-5

In review of DCD Tier 2 Subsection 3.9.2.1.1, the applicant's vibration criteria appear to be based on ASME OM-S/G-2007, Part 3, Paragraph 3.2.1.2; for austenitic stainless steels, the stress limits are obtained from Figures I-9.2.1 and I-9.2.2 of the Mandatory Appendix I to Section III of the ASME BPV Code. In addition, the DCD states that the allowable stress reduction factor provides reasonable assurance that the alternating stress Salt is based on the number of cycles during the design life. In accordance with GDC 1, the applicant is requested to provide a justification whether the fatigue strength at 1E6 cycles with the reduction factor would be conservative for a 60 years operation life running at 1E11 cycles.

03.09.02-6

The staff reviewed DCD Tier 2, Section 14.2 did not find any initial test program (ITP) element that tested the dynamic transient conditions stated above. SRP Section 3.9.2, Item I.1 states that the ITP tests are to confirm that the piping systems, restraints, components, and supports have been adequately designed to withstand flow induced dynamic loadings under the steady state and operational transient conditions anticipated during service. Therefore, the applicant is requested to provide appropriate ITP test programs for each of the transient vibration conditions in accordance with provisions of RG 1.68 and ASME OM-3 such that APR1400 would meet 10 CFR 50, Appendix A, GDC 14 and GDC 15.

03.09.02-7

In DCD Tier 2, Section 3.9.2.1.2 the applicant stated that the thermal expansion tests are developed in accordance with the guidance of ASME OM, Part 7. However, the applicant did not provide a description of the test in the DCD. In addition, SRP Section 3.9.2 states that an acceptable thermal expansion program to confirm the adequacy of the design should include a description of the thermal-motion monitoring program. Therefore, the staff requested the applicant to provide a description of the thermal motion monitoring program for verification of snubber movement, adequate clearances and gaps, the acceptance criteria, and the method regarding how motion will be measured.

03.09.02-8

In the case of multiple-supported equipment in a single structure and/or spanning between structures, an alternate method that can be used is the independent support motion (ISM) approach consistent with guidance given in Section 2 of NUREG-1061, Volume 4. If the ISM method is utilized, all of the criteria presented in NUREG-1061 related to the ISM method should be followed. Therefore, the applicant is requested to specify in DCD Section 3.9.2, consistent with SRP Section 3.7.3 in combining the final structural response from each ISM, multiple-support excitation methods should be implemented in accordance with the staff recommendations on response combinations given in NUREG-1061, Volume 4, Section 2. In addition, the staff notes that in lieu of the response spectrum approach, time histories of support motions may be used as input excitations to the subsystems. The time history approach is considered to provide more realistic results as compared to the more conservative USM or ISM methods.

03.09.02-9

As a result of the audit conducted beginning on June 30, 2015, the staff identified additional detailed information that should be docketed to support the staff's safety finding associated with this section because Tier 2, Section 3.9.2.3.1 does not describe the hydrodynamic model or the method of calculating the forcing functions. In accordance with GDC 1 and 10 CFR 52.47, the applicant is requested to (1) describe how, within the hydrodynamic model, pump pulsation pressure fluctuation was translated to loads on RVI components; and (2) to clarify whether measured test data from one or four pumps were used and justify that the assumption of in-phase pressure fluctuation from four pumps operating is conservative.

03.09.02-10

DCD Tier 2, Section 3.9.2.3.1.1 states that the random hydraulic forcing function is developed by experimental methods and the forcing function is modified to reflect the flow rate and density differences based on an analytical expression found in Reference 45. However, the staff did not find an expression that is physically suitable to modify the random turbulent flow loadings represented by power spectrum density. In accordance with GDC 1 and 10 CFR 52.47, the applicant was requested to provide a description of the experimental methods and the analytical expression that modified the random forcing functions

03.09.02-11

DCD Tier 2, Section 3.9.2.4 states that evaluation of steam generator internals is included in Appendix A of the CVAP report, APR1400-Z-M-14009-P, Rev. 0. The staff reviewed Appendix A of this report and found that it presents an analysis based on the turbulent loading that determines that the stresses in the critical locations are small and acceptable. The analysis, however, does not address the fluid-structural interaction or flow-induced vibration due to cross flow conditions. In light of the recent operating experience with steam generator tube degradation at San Onofre Nuclear Generating Station, the applicant is requested to demonstrate that the APR1400 steam generator tube bundle design will prevent such degradation by (1) discussing the dynamic characteristics of the U-bend assembly including frequencies and mode shapes and describing the U-bend support configuration, or (2) provide the comparison between the APR1400 steam generators and similar steam generators (such as Palo Verde Nuclear Generation Station (PVNGS) Unit 1 replacement steam generators) that have operated without such adverse flow effects. The comparison should include geometry (size); numbers of horizontal and vertical supports and tube-to-support wear type; the steam generator design parameters as listed in APR1400 DCD Tier 2, Table 5.4.2-1; and operating conditions (steam quality, pressure, temperature and flow rates). This information is necessary for the staff to make a finding in accordance with 10 CFR 52.47(a)(22) that operating experience insights have been incorporated into the design.

03.09.02-12

APR1400-Z-M-14009-P, Appendix B, “Vibration Assessment for the Reactor Coolant System Piping and the Piping Attached to the Steam Generator,” states that the vibration assessment program consists of a vibration and stress analysis program, and a flow-excited acoustic resonance measuring and inspection program are performed for the following system piping: (1) reactor coolant system (RCS) piping, (2) main steam system (MS) piping, (3) feedwater system (FW) piping, and (4) condensate system (CD) piping, in conformance with RG 1.20 and SRP Section 3.9.2. The applicant is requested to justify not including vibration assessment for the shutdown cooling and other emergency core cooling system lines, given operating experience at the similar PVNGS plant where a flow-excited acoustic resonance was experienced in the shutdown cooling system, resulting in leaking and failure of an isolation valve. This information is necessary for the staff to make a finding in accordance with 10 CFR 52.47(a)(22) that operating experience insights have been incorporated into the design.

03.09.02-13

DCD Tier 2, Section 3.9.2.5.1 states that the seismic dynamic analysis of the reactor internals including the core is performed separately for the horizontal and vertical directions. The nonlinear horizontal model, as shown in DCD Tier 2, Figure 3.9-16, was constructed to consider gaps between internal components (between core and core shroud, and between core support barrel and reactor vessel) and the large relative displacements occurred during the SSE event. The vertical non-linear model (DCD Tier 2, Figure 3.9-18) was constructed considering the possibility of the core assembly lifting off the support plate. The applicant further states that the mathematical model also includes hydrodynamic effects. However, the staff did not find that Section 3.9.2.5 provided information regarding fluid-structural interactions for the models shown in Figures 3.9-16 and 3.9-18. SRP acceptance criterion II.5.D states that the effects of flow upon the mass and flexibility properties of the system should be addressed. Therefore, the applicant is requested to provide information as to how fluid-structural interaction effects are accounted for in the mass and flexibilities of reactor internals as part of the dynamic modeling.

03.09.02-14

DCD Tier 2, Section 3.9.2.5.1 states that the input excitation to the internals model is the response time-history of the reactor vessel at the internals support determined from the RCS analysis. Coupling effects between the internals and reactor vessel are accounted for by including a simplified representation of the internals with the RCS model. In addition, the applicant stated that the nonlinear seismic response and impact forces for the internals and fuel are determined using the CESHOCK computer program, which is described in the DCD Tier 2, Section 3.9.1. The input excitation for the model is the time-history acceleration of the reactor vessel. The procedures used to account for damping in the analysis of the reactor internals and core are provided in DCD Tier 2, Section 3.7.2.14. Therefore, the applicant is requested to provide justification for using the procedures for analysis of damping provided in DCD Tier 2, Section 3.7.2.14 (which are for the modal analysis of a linear structural system or the proportional viscus damping using direct integration method for a linear system) also for the non-linear dynamic analysis described in DCD Tier 2, Section 3.9.2.5.

03.09.02-15

GDC 1 relates to the design, fabrication, erection, and testing of SSCs in accordance with quality standards commensurate with the importance of the safety function to be performed. To enable the staff to make a conclusion as to the APR1400 design's compliance with GDC 1, specific to the appropriate correlation of tests and analyses of reactor internals, the applicant is requested to provide the following information:

- Comparison of the measured response frequencies with the analytically obtained natural frequencies of the reactor internals for validation of the mathematical models used in the analysis
- Comparison of the analytically obtained mode shapes with the shape of measured motion for identification of the modal combination or verification of a specific mode
- Comparison of the response amplitude time variation and the frequency content from test and analysis for verification of the postulated forcing function
- Comparison of the maximum responses from test and analysis for verification of stress levels
- Comparison of the mathematical model for dynamic system analysis under operational flow transients and under combined LOCA and SSE loadings between APR1400 and valid prototype plant.
- Comparison of measurements and predictions of any adverse flow phenomena (e.g., flow excited acoustic and/or structural resonances) for validation of the model(s) predicting the loading induced by the phenomena

03.09.02-16

SRP Section 3.9.2, SRP acceptance criterion 7 recommends the use of ASME OM-S/G-1990, Part 3 for vibration testing. In accordance with 10 CFR 52.47, the applicant is requested to clarify the edition of ASME OM-S/G being used for the APR1400 design throughout DCD Tier 2 (referenced as the 2007 edition in some locations) and justify any differences from the guidance in SRP Section 3.9.2. In addition, the reference to "OM Part 7" (as well as other similar references to other parts) should be clarified in the DCD to give the complete reference (e.g., OM-S/G-2007, Part 7).