SUPPLEMENTAL 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.: **92-8068**

SRP Section: **03.09.05 – Reactor Pressure Vessel Internals**

Application Section: **3.9.5**

Date of RAI Issue: **07/21/2015**

Question No. 03.09.05-6

1. DCD Tier 2, Section 3.9.5.1.2 states that the control element guide tubes bear the upward force on the fuel assembly hold down devices. The staff needs additional information to make a finding regarding the structural integrity of the control element guide tubes in both the normal operating condition and accident conditions, such that insertability of the CEA is not compromised. The applicant is requested to provide a discussion of the following:

   o How the structural integrity of the control element guide tubes is maintained due to the upward force induced from the fuel assemblies through its stated design life of 60 years, including in events such as an SSE.

   o The mechanism to prevent the control element guide tubes from buckling during both normal operating conditions and other postulated conditions such as an SSE.

2. The staff also requests additional information about design provisions that would prevent misalignment from the fuel assembly guide posts and its impact on the control element guide tubes and insert tubes after each refueling outage. According to the letter referenced above, after the core is defueled and refueled, a total of 964 tubes (both the control element guide tubes and insert tubes) need to fit into the fuel assembly guide posts when the UGS assembly is lifted and put back into the reactor vessel, on top of the fuel assemblies. If there is any misalignment, the bottom end of these control element guide tubes or insert tubes could be pitched or crimped without any indication. This not only could potentially damage the fuel assemblies due to excess compressive force exerted on them, but in the case of a fuel assembly with control element guide tubes, this could also prevent the CEA from inserting into the fuel assembly if a control element guide tube is

pitched or crimped. Operating experience, documented in PNO-IV-96-016, "Damaged Fuel Assembly Found During Core Defueling," dated March 28, 1996, and its supplements detail an event that took place during an refueling outage on March 24-25, 1996 at Palo Verde Unit 2. A fuel assembly could not be removed and was found to be damaged. Damage was also found to the upper guide structure in the area where the damaged fuel assembly was located. The applicant is requested to provide a discussion of the following:

- o Analyses performed for the control element guide tubes and insert tubes in terms of how the structural integrity can be maintained throughout its design life
- o Design provisions to address any misalignment issue during refueling outages when the UGS assembly is put back into the reactor vessel
- o Design provisions to ensure that a similar incident to the Palo Verde event stated above, or other significant operating experience related to reactor internals, will not occur in the APR1400 design
- o Inspection results from similar operating plants that address these issues

Response

The component designer evaluates the stress of control element guide tubes and insert tubes (or control element guide tube extensions) due to the fuel holddown springs, in-water weights and fluid-induced axial and lateral load for Level A, B, C and D conditions. For the Level D condition, the stress as a result of an SSE is considered through the SRSS with other stresses. The deflection limit between the control element assembly and the control element guide tube is evaluated to ensure the CEA insertability during accident conditions. Additionally, the cumulative fatigue usage factor corresponding with a design life of 60 years is calculated taking account normal operation and accident conditions, including an SSE.

The critical buckling stress of the CEA guide tube at the design temperature is evaluated according to ASME NG-3211 and NG-3133. According to NG-3133.6 (a) & (b), the maximum allowable compressive stress shall be taken to meets the minimum buckling stress at the design temperature.

The structural integrity of the control element guide tubes is verified by the same manner as discussed in -response #1.

To ensure that the UGS CEA guide tubes will properly engage the fuel assembly guide post during installation of the UGS with the core in place,; the true position tolerance for the fuel assembly guide post is maintained tightly. The true position tolerance should be within the allowable offset between the CEA guide tube and the fuel assembly guide post.

The APR1400 is new type reactor for domestic plants without any operational history. But the visual inspection results of baseline and post hot functional testing will be used to show that there will be no indications of damage at the outermost tubes, which are subjected to the highest loads and stress by the cross flow on the CEA guide tubes.

Supplemental Response

The true position requirement for the fuel assembly guide post is determined by taking the allowable CEA guide tube to fuel assembly guide post offset and subtracting the positional tolerance stackups between the fuel assembly center post and the fuel assembly outer guide post centerline, and between the CEA guide tube centerline and the Lower Support Structure/Core Shroud centerlines. The allowable CEA guide tube to fuel assembly guide post offset represents the maximum offset between the centerlines of the CEA guide tube and fuel assembly outer guide post which will permit the chamfered surfaces of the tube and post to engage as shown in Figure 6-1. Therefore, the design accounts for the tolerance to allow for insertability. During re-assembly after refueling, it is the responsibility of the licensee to perform a visual or some confirmation that there is no binding or obstruction that could impact insertability.

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Figure 6-1

The worst horizontal deflection of the CEA guide tube is evaluated in accordance to the ASME Code during level D conditions. The maximum deflection of the guide tube is compared with 80% of the allowable offset of the CEA guide tube. In the APR1400 design, the fuel hold down springs provide a vertical force to prevent vertical movement of the fuel relative to the CEA guide tube during level D conditions. Therefore, there is no vertical deflection of the fuel assembly guide post relative to the CEA guide tube.

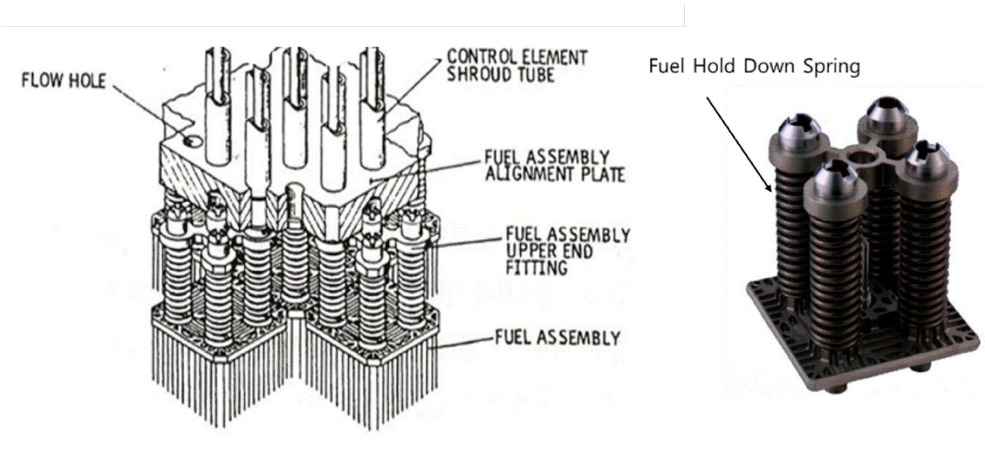

Figure 6-2 Design of CEA Guide Tube to Fuel Assembly

Second Supplemental Response

The operating experience referenced pertaining to Palo Verde was due to swelling of the control rod tip as a result of the materials used. The utility modified their design and KHNP has verified that they have not had any insertion issues since their modifications have been implemented.

KHNP reviewed the operating history of the Korean domestic plants with CEA and guide tube designs similar to that of the ARR1400 and have confirmed that no failures have occurred on these components that would prevent control rod insertion.

Third Supplemental Response

The deflection calculation of the guide tube does not take buckling into account. The maximum deflection (worst case deflection) of the guide tube is calculated using the Level D loads which occur on the lateral deflection of the guide tube. Theoretically speaking, if the guide tube is deflected, it cannot buckle. Therefore, buckling does not occurred in the guide tube. However, the buckling analysis of CEA guide tube is conservatively evaluated in accordance with ASME Code Section III, Subsection NG-3211 and NG-3133

The buckling analysis is performed using Subsection F-1334.3. The details of the evaluation are shown below.

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Figure 6-3 shows that the guide tubes are welded on both ends; however, the horizontal movement of the bottom side of the tube ends are not fixed because they are welded on to the FAP (Fuel Alignment plate). Therefore, a translation free end condition is considered conservative. The theoretical effective length of a tube is 1.0; however, K=1.2 is used conservatively (see Table 6-1). The comparison of the results based on the effective length factor is shown in Table 6-2.

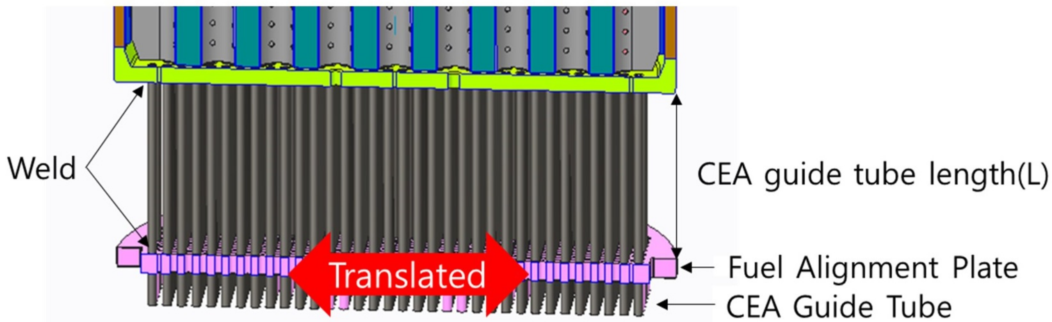

Figure 6-3. CEA Guide Tube

Table 6-1. Effective Length Factor Table (AISC 2010)

TABLE C-A-7.1
Approximate Values of Effective Length Factor, *K*

	(a)	(b)	(c)	(d)	(e)	(f)
Buckled shape of column is shown by dashed line						
Theoretical *K* value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design value when ideal conditions are approximated	0.65	0.80	1.2	1.0	2.1	2.0
End condition code	Rotation fixed and translation fixed Rotation free and translation fixed Rotation fixed and translation free Rotation free and translation free					

American Institute of Steel Construction (2010). *Specification for Structural Steel Buildings*, 14th edition, Chicago, IL.

Table 6-2. Comparison of Result according to the Effective Length Factor

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Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Report

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