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.:	**275-8294**
SRP Section:	**04.02 – Fuel System Design**
Application Section:	**4.2**
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Question No. 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.

Response - (Rev.1)

The stress limits of the normal operation and anticipated operational occurrence (AOO) condition will be used to assure that the components do not deform severely enough to interfere with control rod insertion at the faulted conditions. The fuel assembly components for CEA insertion are guide thimble, outer guide post, adapter plate and holddown plate. The stress limits of fuel assembly components for CEA insertion are:

(a) $P_m \leq S_m$

(b) $P_m + P_b \leq 1.5 \cdot S_m$

Where:

P_m = primary membrane stress intensity,
P_b = primary bending stress intensity
S_m = allowable design stress intensity defined in the ASME Section III

DCD APR1400-K-X-FS-14002-P Rev.1, technical report APR1400-Z-M-NR-14010-P Rev.1 and topical report APR1400-F-M-TR-13001-P Rev.0 will be revised to add the limits of the fuel assembly components as indicated in attachment 1, 2 and 3.
Based on analyses of Seismic and LOCA events, the stress intensity results of the fuel assembly components for CEA insertion are less than the normal operation and AOO limits. Satisfying the normal operation and AOO limits ensures that no permanent deformation of the guide tubes within manufacturing tolerances will occur, so there is no impact on CEA insertability. Evaluation results of the fuel assembly components for the CEA insertion will be included in technical report APR1400-Z-M-NR-14010-P Rev.0 as indicated in attachment 3.

Impact on DCD

DCD Rev.1 Section 4.2.1.5.3 will be revised as indicated in Attachment 1.

Impact on PRA

There is no impact on PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical Report APR1400-Z-M-NR-14010-P Rev.1 will be revised as indicated in Attachment 2.
Topical Report APR1400-F-M-TR-13001-P Rev.0 will be revised as indicated in Attachment 3.

c. Two-thirds of the specified minimum yield strength (S_y) at room temperature

d. Ninety percent of the yield strength at temperature

For the zirconium alloy, the design stress intensity on the unirradiated yield strength is conservative.

The design stress intensity of zirconium alloy is defined as follows:

a. Two-thirds of the minimum yield strength at temperature

4.2.1.5.3 Postulated Accident Loads

Worst-case abnormal loads during postulated accidents are represented by seismic and LOCA loads. For these conditions, the reactor is able to be brought to a safe shutdown condition, and the core is kept subcritical with the acceptable heat transfer geometry. This requirement is met by demonstrating that, under the most severe anticipated loading of fuel assemblies for postulated accidents, no damage to the fuel assembly structure is severe enough to prevent a coolable geometry from being maintained or to preclude CEA insertion.

The fuel assembly structural component stresses under faulted conditions are evaluated using primarily the methods in Appendix F of ASME Section III (Reference 23). The faulted condition stress limits for fuel assembly structural components are:

a. General primary membrane stress intensity limit: S_m'

b. Primary membrane plus bending stress intensity: 1.5 S_m'

Where:

S_m' = the lesser value of 2.4 S_m and 0.7 S_u

Additionally the stresses of the fuel assembly components for the CEA insertion are evaluated using the normal operation and AOO stress limits to assure that the components do not deform severely enough to interfere with CEA insertion even under the faulted conditions. The fuel assembly components for CEA insertion are guide thimble, outer guide post, adapter plate and holddown plate. The stress limits of fuel assembly components for CEA insertion are same as the normal operation and AOO stress limits in subsection 4.2.1.5.2.

4.2.1.6 In-Core Control Components

$P_m \le S_m'$
$P_m + P_b \le 1.5 \cdot S_m'$

Where,
P_m = calculated primary membrane stress
P_b = calculated primary bending stress
S_m = allowable design stress intensity defined in the ASME Section III
S_u = minimum ultimate tensile strength at unirradiated condition
S_m' = allowable design strength for the accident conditions (a smaller value of 2.4 S_m and 0.7 S_u)

(3) Evaluation

The structural integrity of the PLUS7 components is verified in Section 2.3 for all conditions.

The fuel assembly evaluation for seismic and LOCA loads is performed in accordance with the NRC licensed CE methodology (Reference 2-1). The fuel assembly model and characteristics were determined as analysis of fuel assembly mechanical test and used to the core analysis predicted fuel assembly deflected shapes and grid impact forces. Grid buckling strength was determined from dynamic impact testing for PLUS7 grids, and compared with predicted grid impact forces. The stresses for remaining components during seismic and LOCA are calculated through deflection shapes and axial loads, and then evaluated against each stress criteria. The evaluation of fuel assembly for seismic and LOCA loads will be addressed in DCD tier 2, Section 4.2.

2.2.2.2 Rod-to-Top Nozzle Axial Clearance

(1) Basis

Additionally the stresses of the fuel assembly components for the CEA insertion are evaluated using the normal operation and AOO stress limits to assure that the components do not deform severely enough to interfere with control rod insertion even under the postulated accident conditions. The fuel assembly components for CEA insertion are guide thimble, outer guide post, adapter plate and holddown plate. The stress limits of fuel assembly components for CEA insertion are same as the normal operation and AOO stress limits.

time.

(3) Evaluation

Based on the calculation of the axial gap between the fuel rod and top nozzle considering their irradiation growths, the axial clearance is maintained during the fuel lifetime. The PLUS7 PSE results confirmed the sufficient gap after three cycles of irradiation as shown in the Section 4.2.3.

2.2.2.3 Hydraulic Stability

(1) Basis

Since the fuel assembly lift-off may cause the fuel assembly and in-core structure failure, the fuel assembly shall not be lifted off during the normal operation. The fuel assembly and fuel rod vibration causing the fuel failure shall not occur over the full range of flow rates of the plant.

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Results of the fuel assembly stress analysis in this section did not exceed each stress limit during postulated accidents. In addition, as a result of core analysis in Section 3 and 4, grid impact loads did not exceed the grid crush strength in Section 5.

Consequently, the fuel assembly satisfied the requirements to maintain control rod insertability and core coolability.

Additionally the stresses of fuel assembly components for the CEA insertion are compared with the normal operation and anticipated operational occurrence (AOO) stress limits to ensure the CEA insertability. The stresses of guide thimble, outer guide post, adapter plate and holddown plate did not exceed the stress limits of normal operation and anticipated operational occurrence (AOO) condition. It is evaluated that these components will not interfere with control rod insertion under the postulated accident conditions.

7. FAULTED CONDITION CRITERIA FOR FUEL ASSEMBLY PERFORMANCE EVALUATION

7.1 Introduction

This section presents the criteria that must be met for fuel assembly components, such as nozzles and guide thimbles, during seismic and pipe rupture events. According to Reference 7-1, to meet the requirement related to control rod insertability and core coolablility for postulated accidents (seismic and ... h adequate ... the fuel ... re with control

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(a) $P_m \le S_m$

(b) $P_m + P_b \le 1.5 \cdot S_m$

... lents, the criteria ... in the following ... wable stresses would be based on ASME Boiler and Pressure Vessel Code values.

7.2 Grid

The grids have an important role for coolable geometry of the fuel assembly in maintaining the appropriate spacing between adjacent fuel rods. The evaluation of grids for this function is performed by comparing the peak impact load for the grid in the core analysis with the lateral impact strength of the grid. This grid crush strength is determined by the grid impact test described in Appendix A and by analyzing the test results described in Section 5.

7.3 Components Except Grid

As described in Section 2, the fuel assembly is made from Type 304 stainless steel including Grade CF-3, Inconel 718, and zirconium alloy. The structural integrity of these components to withstand the loads during seismic and pipe rupture accidents are evaluated by comparing the calculated stress intensities for each component with stress limits defined by:

(a) $P_m \le S_m'$

(b) $P_m + P_b \le 1.5 \cdot S_m'$

S_m = allowable design stress intensity defined in the ASME Section III

Where:

P_m = primary membrane stress intensity,

P_b = primary bending stress intensity

S_m' = design intensity value for faulted conditions.

~~For holddown springs that are fabricated from Inconel 718 wire, their performance is evaluated by calculating the shear stress resulting from the spring being compressed to its solid height. This calculated shear stress must not exceed the yield strength in shear for this material.~~

7.4 References for Section 7

7-1 NUREG-0800, Standard Review Plan Section 4.2 Rev. 03, “Fuel System Design,” March 2007.