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.:	**432-8377**
SRP Section:	**19 - Probabilistic Risk Assessment and Severe Accident Evaluation**
Application Section:	**-**
Date of RAI Issue:	**03/08/2016**

Question No. 19-66

10 CFR 52.47(a)(23) states that a design certification (DC) application for light-water reactor designs must contain an FSAR that includes a description and analysis of design features for the prevention and mitigation of severe accidents, e.g., challenges to containment integrity caused by core-concrete interaction, steam explosion, high-pressure core melt ejection, hydrogen combustion, and containment bypass. Revise the design control document (DCD) as necessary.

The following refer to APR1400-E-P-NR-14003-P, “Severe Accident Analysis Report,” Rev. 0, Appendix C-1, “Severe Accident Analysis Report for HPME/DCH:”

a. Section 4.2.1 states that “the initial mass of UO_2 in melt at vessel breach, the fraction of Zr oxidized and variations in the coherence ratio were quantified as probability density curves.” However, APR1400-E-P-NR-14003-P does not provide any probability density curves used. Provide probability density curves used for the initial mass of UO_2 in melt at vessel breach, the fraction of Zr oxidized and variations in the coherence ratio.

b. Section 4.2.2 lists 26 input parameters without their values used for analysis. Provide input values used for these parameters.

Response - (Rev. 1)

a. Figure 1 through 5 show the probabilistic density curves used for the initial mass of UO_2 in melt at vessel breach, the fraction of Zr oxidized and variations in the coherence ratio. The detailed information for each variable is described as below.

1. Mass of UO_2 in the Lower Plenum

Non-Proprietary

TS

TS

2. Fraction of Zr Oxidized

TS

3. Variation in the Coherence Ratio

TS

b. The values of 26 input parameters listed in Section 4.2.2 are shown as Table 4.

Table 1 Distribution of Molten Mass of UO_2 in the Lower Plenum for Scenarios V and Va

TS

Table 2 Distribution of Molten Mass of UO_2 in the Lower Plenum for Scenarios VI

TS

Table 3 Distribution of Oxidation Fraction of Initial Zr Inventory in the Core

TS

Table 4 Input Parameters for V, Va and VI Scenarios in DCH Analysis

TS

TS

Figure 1 Distribution of Mass of UO2 in the Lower Plenum for Scenario V and Va

TS

Figure 2 Distribution of Fraction of Zr Oxidation for Scenario V and Va

TS

Figure 3 Distribution of Molten Mass of UO_2 in the Lower Plenum for Scenario VI

TS

Figure 4 Distribution of Fraction of Zr Oxidation for Scenario VI

TS

Figure 5 Variation in the Coherence Ratio Distribution (cohdis) for Scenario V, Va, and VI

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 Reports

Technical report for severe accident analysis (Doc. No. APR1400-E-P-NR-14003-NP) Appendix C-1 will be revised to reflect the response of this RAI.

4.2 DCH model for APR1400

DCH induced loads in APR1400 were calculated using the TCE model. In the calculations, three scenarios were considered which are described in NUREG/CR-6338 (Reference 46).

The APR1400 cavity was categorized as "Zion-like" cavity with channel linking with the subcompartment. As shown in Figure 4-1, there are two flow paths in the APR1400 cavity design. The flow path through reactor vessel annulus (blue arrows) is directly connected with upper dome compartment. And the flow path linking with subcompartment was considered to convoluted flow path through corium chamber room (red arrows), because the vertical flow path through ICI chase compartment is blocked by seal table. Therefore, the APR1400 cavity is considered as "Zion-like" slanted cavity in the DCH analysis.

4.2.1 Generation of probabilistic distribution and sampling for uncertain input parameters

The high uncertain parameters considered in the TCE model are to be quantified as probability density functions. In this calculation, initial mass of UO_2 in melt at vessel breach, fraction of Zr oxidized, coherence ratio, containment fragility curve are selected as probabilistic input parameters. The initial mass of UO_2 in melt at vessel breach, the fraction of Zr oxidized and variations in the coherence ratio were quantified as probability density curves. For the TCE model analysis, each probabilistic input parameter is sampled using the LHS (Latin Hypercube Sampling) method. In this calculation, the 10,000 samples per each probabilistic input parameter are used.

4.2.2 Quantification of point input parameters

Referring to the specific design information of APR1400 and the initial and boundary conditions for selected scenarios, the point input parameters are quantified. In this calculation, the point input parameters are as follows:

- Lower head wall thickness (m)
- Lower plenum volume (m^3)
- Initial lower head hole diameter (m)
- Lower head wall temperature at VB (K)
- Mass of Control Rod Material in melt (metric ton)
- Mass of UO_2 in core (metric ton)
- Mass of Zr in core (metric ton)
- Mass of steel in lower plenum (metric ton)
- Reactor cavity specific multiplier in coherence ratio
- RCS pressure at VB (MPa)
- RCS volume (m^3)
- RCS temperature at VB (K)
- Containment pressure at normal operation (MPa)
- Containment temperature at normal operation (K)
- Containment pressure at VB (MPa)
- Containment temperature at VB (K)
- Containment free volume (m^3)

- Reactor cavity free volume (m^3)
- Fraction of debris remaining in subcompartment
- Volume fraction of subcompartment
- Auto-ignition temperature (K)
- Temperature of debris melt (K)
- Fraction of Zr block relocated
- Fraction of H_2 generated in RCS that stays in RCS
- Melt fraction ejected into the reactor cavity
- Fraction of ejected melt dispersed from reactor cavity

4.2.3 TCE calculation

The TCE calculation is performed to evaluate the DCH loads. The probabilistic and point input parameters are used to evaluate the equations. In each trial the calculated DCH pressure is compared against the failure pressure sampled from the containment fragility curve. The process is repeated 10,000 times and the number of cases where the DCH pressure exceeds the containment failure pressure is recorded. The number of "failed" cases divided by 10,000 gives the containment failure probability.

Add the Figure 4-1(next page)

TS

Figure 4-1 Paths of Gas and Corium Flows in DCH