ATTACHMENT 5

**Holtec International Document RRTI-2127-001R0,
"Holtec Responses to Request for Additional Information for
Quad Cities Criticality Insert Analysis"
(Non-Proprietary Version)**

NRC Request 1-4

Section 2.3.1.1 of HI-2125245 Revision 4 mentions MOX fuel. Provide a description of the MOX fuel assemblies stored in the Quad Cities SFPs. Provide the justification of how the HI-2125245 analysis bounds those MOX fuel assemblies, include descriptions of the analysis that was performed in support of the justification.

Response

Section 2.3.1.1 of HI-2125245 Revision 4 mentions MOX fuel [redacted].

Specifications for these MOX assemblies are provided in Table 5.1(d) of HI-2125245 Revision 4. Additional specification for these bundles can be found in Figures 1 and 2 below in this response. The evaluation of all the legacy fuel designs is further discussed in Appendix A of HI-2125245 Revision 4 [redacted] Therefore, these bundles are bounded by the analysis.

Figure Proprietary

Figure Proprietary

NRC Request 1-5

Section 2.3.1.1.2 of HI-2125245, Revision 2 discusses the isotopic compositions used in the analysis. The text implies the analysis is modeling a number of short lived isotopes and volatile and gaseous isotopes not explicitly mentioned in the discussion of the analysis assumptions. Provide a justification for using these short lived, volatile, and gaseous isotopes as well.

Response

Section 2.3.1.1.2 of HI-212545, Revision 2 and 4 discusses the isotopic composition used in the analysis with respect to spent fuel cooling time [redacted] These studies are provided below, using the design basis lattice (SVEA-96 Optima2, bundle QI22 with 40 mil offset lattice type 146, see Figure 5.1). For the purpose of these studies, MCNP calculations have been added to this RAI response using the design basis core operating parameters (see Table 5.2(a)). The results of these studies are presented in Table 1 below [redacted].

Section 2.3.1.1.2 of HI-212545, Revision 2 and 4 also presents the discussion related to the depletion calculations performed with CASMO-4 to determine the spent fuel isotopic composition. The isotopes that are used from the CASMO-4 depletion calculations in MCNP5 are presented in Table 5.4(b). From the fission products shown in Table 5.4(b) it can be seen that [redacted] To determine the reactivity worth associated with these three gaseous nuclides and four volatile nuclides, studies have been performed using MCNP. These representative studies are a comparison of the reactivity of calculations without these gaseous and volatile nuclides compared to the reactivity of the design basis case from HI-212545 Table 7.4, which consider the presence of all these nuclides. [redacted] The results presented in Table 2 below show the reactivity worth of these gaseous and volatile nuclides. [redacted] A total reactivity worth of no more than [redacted] delta k has been determined. Note a very small increase in the uncertainty [redacted] was determined but this is insignificant when combined with the statistical combination of other uncertainties of [redacted] shown in Table 7.11 and Table 7.14 of HI-212545, Revision 2 and 4.

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]						[redacted]	[redacted]

[redacted]

NRC Request 1-6

Section 2.3.5.4 of HI-2125245, Revision 2 discusses the various fuel orientations within the storage cells that were considered. The report also indicates fuel assemblies at Quad Cities will have radial gradients based on actual fuel pin loading and rodded operation. It is not clear from Section 2.3.5.4 that the fuel orientations considered included the case where the most reactive quadrant of the fuel assemblies were all turned toward each other. Was this case considered in Section 2.3.5.4, and if so identify the case.

Response

Section 2.3.5.4 of HI-2125245 Revision 2 and 4, second paragraph discusses five cases analyzed to assess the fuel assembly orientation most limiting case. The cases are presented in Figure 2.9(a) through Figure 2.9(e). Figure 2.9(a) through Figure 2.9(e) are color coded by sub-lattice for clarification. The bounding case, used as the design basis orientation, is shown in Figure 2.9(a). The remaining figures show variations on this orientation with the color scheme providing clarification. Assuming that the quadrant which is located adjacent to the control blades in the core is the most reactive, the case which orients the four fuel assembles with this quadrant adjacent to each other is shown in Figure 2.9(e). The results of the calculations for all the five cases are presented in Table 7.9(b). For each of the four alternative orientations, the results show that the reactivity is less than the reference case (i.e. the design basis calculation orientation is bounding). However, in some cases the results may be slightly positive if the 95/95 uncertainty is applied. Therefore, the results are applied as a bias (truncated to 0) and a bias uncertainty (see Table 7.11). All other calculations use the bounding reference case.

NRC Request 1-7

HI-2125245, Revision 2 discusses the effect of fuel channel bulging and bowing. This section indicates the reactivity effect is bounded by abnormal/accident scenarios. The presence of fuel channel bulging and bowing would be part of the normal condition of the SFP storage system and needs to be included in the estimation of reactivity under normal conditions. The NRC staff considers it inappropriate to use accident conditions to bound normal operating conditions, especially when the normal operating conditions would be the starting point for subsequent abnormal/accident scenarios. Revise the NCS to account for fuel channel bulging and bowing under normal conditions.

Response

[redacted]

[redacted]

NRC Request 1-11

Section 2.9 of HI-2125245, Revision 2 discusses reconstituted fuel assemblies. With respect to reconstituted fuel, provide the following information:

a) The text indicates that the current inventory of reconstituted fuel at QCNPS had fuel rods replaced with either like for like fuel rods or stainless steel. The analysis concludes there was no increase in reactivity for these legacy reconstituted fuel assemblies. Justify the basis for that conclusion.

b) The text indicates that future reconstitutions will only use stainless steel pins. Elsewhere in the analysis it is indicated that the Optima2 fuel assembly is under moderated. Replacing a fuel rod with a stainless steel pin reduces the amount of under moderation. This potential increase in reactivity may be offset by the additional neutron absorption in the stainless steel pin. Describe any limitations on the number or material of the stainless steel pins. Explain how did those conclusions were reached.

Response

Part a: [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Part b: Future reconstitutions were not meant to be considered by this analysis. Any future reconstitutions will be fully evaluated to ensure that any future fuel rod replacements or other changes to originally designed fuel assembly configuration are explicitly modeled to confirm they are bounded by the HI-2125245 analysis and will be processed under 50.59.

NRC Request 1-12

HI-2125245, Revision 2 includes the results of numerous cases that were run to support the determination of the bounding lattice used in the analysis. However, from the information provided it is unclear to the NRC staff what the particular details of each case are and how they relate to current QCNPS fuel.

Response

The QCNPS have used many different BWR fuel designs since power operations began. The criticality analysis presented in HI-2125245, Revision 2 and Revision 4 performed evaluations for all legacy fuel bundles (current SFP population) as well as current bundles. The evaluations were performed to determine the bounding fuel design bundle lattice to be used as the design basis fuel assembly (references [2] and [6] of HI-2125245, Revision 2 and Revision 4). The design basis fuel assembly evaluations were performed using fuel vendor supplied data, engineering judgment, CASMO-4 calculations and MCNP calculations. The methodology approach has been discussed in HI-2125245, Revision 2 and Revision 4, in the following sections:

- Section 2.3.1 "Design Basis Fuel Assembly" (see also Section 7.1)
- Section 2.3.1.2 [redacted] (see also Section 7.1.1)
- Section 2.3.1.3 "Determination of the Design Basis Fuel Assembly Lattice" (see also Section 7.1.2)
- Appendix A [redacted]
- Appendix B [redacted]
- Appendix C [redacted]

In this RAI response (as well as RAI 14, 16, 18 and 20 as noted below, which are all related to this RAI topic), the above referenced sections from HI-2125245, Revision 2 and Revision 4 will be more meticulously explained so that the method used to determine the design basis lattice is clear.

Section 2.3.1 "Design Basis Fuel Assembly"

In general, the approach to determine the design basis lattice for use in the analysis is to compare the reactivity of each lattice such that the most reactive lattice can be determined. Much of the legacy fuel population is low enriched and thus has very low reactivity. Additionally, for many of the legacy fuel lattices, the fuel vendor provided Standard Cold Core Geometry (SCCG) values which allow a reactivity comparison. Therefore for many of the older, low reactivity legacy bundles, engineering judgment can be used and there is no need to perform exhaustive calculations for each and every lattice. However, each fuel bundle design is accounted for, and a proper evaluation is performed to ensure that every lattice is bounded by the final design basis

lattice. After the design basis lattice was selected, additional evaluations were performed and documented in Appendix A through Appendix C to support the method to select the design basis fuel bundle and lattice.

Section 2.3.1.2 [redacted]

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[redacted]

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Section 2.3.1.3 "Determination of the Design Basis Fuel Assembly Lattice"

[redacted]

Appendix A [redacted]

[redacted]

[redacted]

Appendix B [redacted]

[redacted]

Appendix C [redacted]

[redacted]

[redacted]

Summary

In summary, the method to determine the design basis lattice relied upon fuel vendor data, lattice enrichment data, engineering judgment, CASMO4 calculations, MCNP calculations and supporting calculations found in three appendices. The method has considered every fuel design and lattice type and performed a rigorous evaluation to determine the two most reactive fuel designs. The most reactive fuel design is much more reactive than the next most reactive design, even when additional impacts are considered such as core operating parameters, eccentric positioning, and the reactivity effect of the channel. With respect to the most reactive design, all Optima2 lattices have been considered in the design basis rack geometry with MCNP under bounding core operating parameters. Therefore, the method used is appropriate and the correct design basis lattice has been selected to be used for all additional calculations to determine compliance with the regulatory limit. No further calculations are therefore required with any of the other legacy fuel bundles. Specifically, in response to RAI 14, the above supporting conclusions are directly applicable to why it is not necessary to consider the fuel assembly manufacturing tolerances for the next most reactive fuel design, the GE14.

NRC Request 1-13

Section 2.3.1.4 of HI-2125245, Revision 2 discusses a series of calculations performed to demonstrate that certain simplifications in the SVEA-96 Optima2 fuel geometry as modeled in CASMO-4 (due to code limitations) do not have a significant impact on the calculated rack k-infinity. The calculations were performed based on a single fuel lattice. The licensee needs to provide the technical basis for concluding that this finding of no significant impact will apply broadly to all expected lattices (i.e., lattices with different compositions, gadolinia loading, and locations of gadolinia pins).

Response

As discussed in Section 2.3.1.4, the CASMO-4 model geometry of the SVEA-96 Optima2 fuel differs from the SVEA-96 Optima2 fuel as follows:

[redacted]

All of the above simplifications are applicable to and the same for all Optima2 lattices [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Figure Proprietary

Figure Proprietary

Figure Proprietary

Figure Proprietary

NRC Request 1-14

Section 2.3.4.1 of HI-2125245, Revision 2 addresses fuel manufacturing tolerance biases for the SVEA-96 Optima2 fuel assembly. However, the tolerances associated with other fuel lattice types are not addressed. Provide a statement explaining why any potential increase in fuel manufacturing tolerance bias for a different fuel assembly design are not expected to be larger than the reactivity difference between the limiting lattice(s) for that fuel assembly design compared to the limiting SVEA-96 Optima2 lattice.

Response

Please see the response to RAI 12.

NRC Request 1-15

Revision 4 of HI-2125245 removed part of Section 2.7 as included in Revision 2, which discussed a new approach in which super-lattices could be used to qualify future lattices. However, superlattices are still used in the analyses. Given that the super lattices result in significantly less margin to the regulatory limit, please indicate if the proposed revision to the current licensing basis of Quad Cities is to be based on the design basis lattice, or on the super lattices. Provide clarification.

Response

The super lattices have been removed from the analysis since they are not needed to support current Quad Cities fuel inventory. All future fuel bundle designs will be explicitly evaluated using the same methodology as the basis of HI-2125245 per the 50.59 process. As a result, multiple sections, tables, figures and a subset of calculations have been updated. The following is a summary these changes. The updated maximum calculated reactivities for both normal and accident conditions do not exceed the regulatory limit of 0.95, which includes a margin of [redacted] for normal condition, and [redacted] for abnormal and accident conditions with a 95% probability at a 95% confidence level. The following sections in HI-2125245 have been revised:

- Section 2.3.8 for minor editorial changes
- Section 2.6 for minor editorial changes
- Section 2.7 removed, subsequent sections renumbered
- Section 5.1 for minor editorial changes
- Section 7.1.10 for minor editorial changes
- Section 7.6 removed and replaced, subsequent section renumbered
- Section 8 updated to reflect new analysis results

[redacted]

- Section S1.9 was updated to reflect new analysis results

Additionally, the following Tables have been updated:

[redacted]

[redacted]

- Table 7.16 was deleted and subsequent tables renumbered

[redacted]

Additionally, the following Figures have been updated:

[redacted]

Refer to the summary of revisions page in HI-2125245 Revision 5 for a full list of changes.

NRC Request 1-16

Provide more detail for the technical basis and assumptions inherent in the criteria described in HI-2125245, Revision 2 to select lattices for evaluation using the in-rack k-infinity calculational method. In particular, explain why more lattices were not selected for evaluation and why it is appropriate to conclude that the most limiting in-rack k-infinity will be found among the candidate lattices.

Response

Please see the response to RAI 12.

NRC Request 1-17

CASMO-4 is used to perform depletion calculations which provide the isotopic compositions used as inputs to the MCNP5-1.51 NCS analyses. Describe how CASMO-4 is qualified for performing depletion calculations with the SVEA-96 Optima2 fuel assembly; given that a different code is used for NRC-approved reload analysis methods. Address the fact that the documented CASMO-4 k-infinity values show a persistent bias relative to MCNP5-1.51 results for the same fuel lattices. If CASMO-4 is not formally qualified for this purpose, then explain why use of the 5% depletion uncertainty described in DSS-ISG-2010-01 remains applicable.

Response

The use of CASMO-4 by Holtec to perform depletion calculations to determine isotopic compositions for nearly every type of fuel assembly has a long history and has been used for virtually every Holtec International application for many years. [redacted] CASMO-4 is used for reload analysis with the SVEA-96 Optima2 fuel assembly [redacted]. Therefore, the isotopic compositions calculated using CASMO-4 are acceptable and the depletion uncertainty is applicable.

NRC Request 1-18

The screening calculations performed as reported in HI-2125245, Revision 2 assumes "nominal" operating conditions. After the design basis lattice is selected, then different operating conditions are investigated to establish a limiting set of "design basis" operating condition. Provide the technical basis for concluding that the limiting operating conditions used as input to the NCS analyses are solely a consequence of the fuel assembly geometry and/or fuel assembly design specific characteristics. In other words, if the "design basis" operating conditions differs for different fuel assembly designs, Explain how this changes the lattice(s) selected as a result of the screening calculations.

Response

Please see the response to RAI 12.

NRC Request 1-20

Section 2.2.2 of HI-2125245, Revision 2 indicates that a validation of CASMO-4 to determine a bias and bias uncertainty is not necessary because CASMO-4 is not being used for the design basis k-eff calculations. CASMO-4 is being used to screen out lattices in order to limit the number of MCNP5-1.51 calculations that need to be performed. The underlying assumption is that any bias between CASMO-4 and MCNP5-1.51 results will tend to be consistent, so the relative values for CASMO-4 can be used to identify the most reactive lattices. Provide support for the assumption that the most reactive lattice determined by CASMO-4 will produce the maximum in-rack reactivity using MCNP5-1.51.

Response

Please see the response to RAI 12.

NRC Request 1-21

HI-2104790, Revision 1 provides a detailed description of the benchmarking of MCNP5-1.51, trend analysis, and statistical analysis as discussed in NUREG/CR-6698, "Guide for Validation of Nuclear Criticality Safety Calculational Methodology," issued January 2001. It is not clear how the critical benchmarks and experiments bound the Area Of Applicability (AOA) for the fuel lattices being studied with respect to specific characteristics of the geometry of the SVEA-96 Optima2 lattice. Provide a discussion of how the AOA is adequately bounded for the specific characteristics of the SVEA-96 Optima2 fuel lattice.

Response

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