UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 14, 2020

Mr. Brian Seawright
Holtec International
1 Holtec Blvd
Camden, NJ 08104

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE MODEL NO. HI-STAR 100MB PACKAGE

Dear Mr. Seawright:

By letter dated October 25, 2019, you submitted an amendment request to Certificate of Compliance No. 9378 for the Model No. HI-STAR 100 MB. Your application was accepted for review on January 23, 2020.

The staff has determined that further information is needed to complete its technical review. The information requested is listed in the enclosure to this letter. We request you provide this information by May 30, 2020. If you are unable to meet this deadline, you must notify us in writing no later than May 15, 2020, of your new submittal date and the reasons for the delay. The staff will then assess the impact of the new submittal date and notify you of a revised schedule.

Please reference Docket No. 71-9378 and EPID- L-2019-LLA-0242 in future correspondence related to this licensing action. If you have any questions regarding this matter, please contact me at 301-415-7505.

Sincerely,

Pierre Saverot

Pierre Saverot, Project Manager
Storage and Transportation Licensing Branch
Division of Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9378
EPID - L-2019-LLA-0242

Enclosure:
Request for Additional Information

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE MODEL NO. HI-STAR 100MB PACKAGE, DOCUMENT DATED:

DISTRIBUTION: SFST r/f ADimitriadis, RI; BDesai, RII; MKunowski, RIII; GWarnick, RIV

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Request for Additional Information
HOLTEC INTERNATIONAL
Docket No. 71-9378
Model No. HI-STAR 100MB Package

By letter dated October 25, 2019, Holtec International submitted an amendment request to Certificate of Compliance No. 9378 for the Model No. HI-STAR 100 MB transportation package.

This request for additional information (RAI) identifies information needed by the staff in connection with its review of the application.

Each individual RAI describes information needed by the staff to complete its review of the application and to determine whether the applicant has demonstrated compliance with the regulatory requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71.

The requested information is listed by chapter number and title in the package application. NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," was used for this review.

CHAPTER 1 GENERAL INFORMATION

1-1 Specify tolerances on the licensing drawings.

NUREG/CR-5502, "Engineering Drawings for 10 CFR Part 71 Package Approvals," provides guidance for preparing drawings of transportation packages and states that engineering drawings should have tolerances that are consistent with the package evaluation. Without tolerances, structural components could be fabricated in a way that alters load path, energy absorption capability of the component etc.

The staff recognizes that the applicant desires flexibility in the package design by allowing for dimensional variation that does not impact the package's design function (e.g., components fabricated slightly out of manufacturing tolerance). However, this flexibility may be achieved by specifying tolerances in the package design drawings that are large enough to bound reasonable variations in fabrication (see guidance in the staff's ISG-20). Using nominal dimensions versus dimensions at the bounding tolerances is a non-conservative departure from practices typically used in 10 CFR Part 71 applications. Also, the applicant is using design tolerances as margin to balance out other possibly non-conservative uncertainties, and the staff finds this to be an inappropriate consideration of design tolerances.

This information is required to demonstrate compliance with 10 CFR 71.33(a).

CHAPTER 2 MATERIALS AND STRUCTURAL REVIEW

2-1 Provide the material and welding specifications for each of the important-to-safety (ITS) structures, systems and components (SSCs) and welded joints, respectively, in the drawing for the Impact Limiter Version LW.

The Bill of Materials for the Impact Limiter Version LW contains ITS components for which the materials code or standard is not provided. These include austenitic stainless steel and low-alloy steel plates and aluminum 6061-T6 (no standard cited) crush material and bushings.

Absent a materials code or standard, it is unclear to the staff how these materials will be procured to ensure that the mechanical properties used in the structural analysis are met.

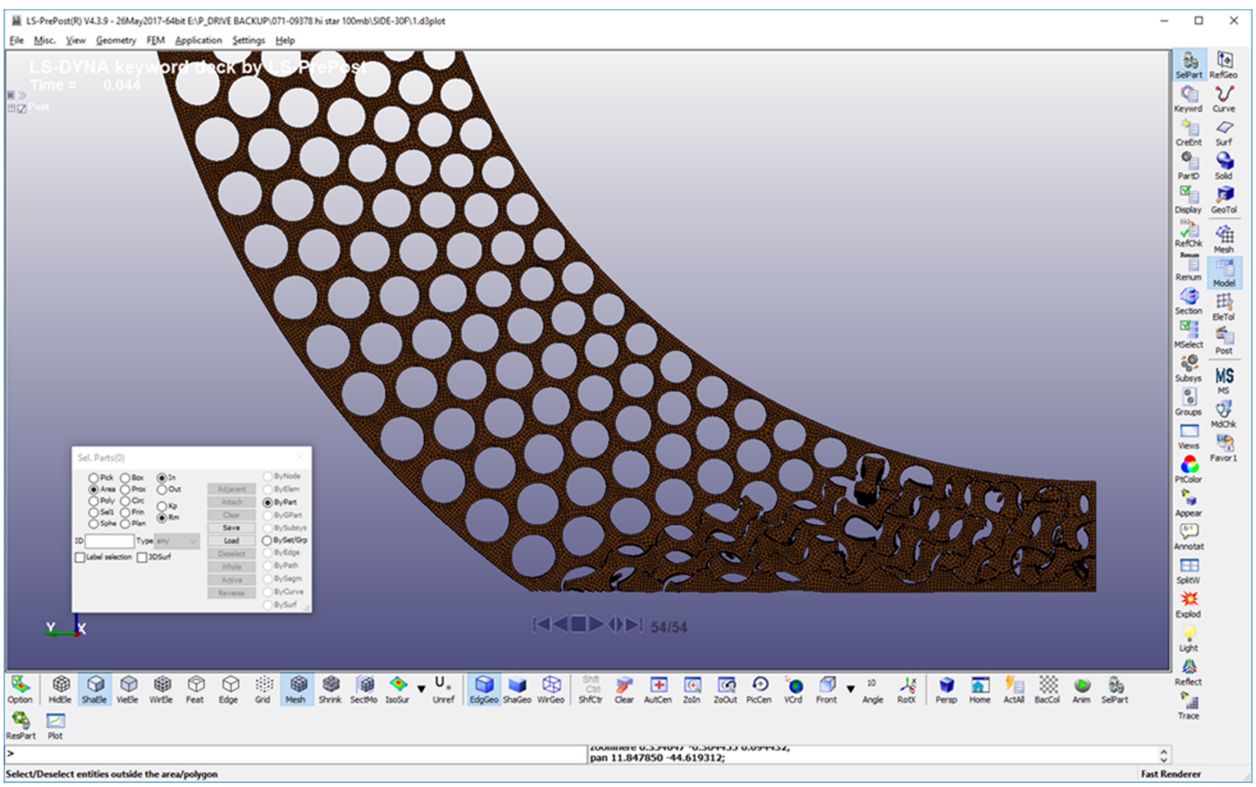
In addition, the drawings do not appear to describe the weld specifications for each of the joints. A weld symbol is provided only for one joint, between the lower strong back plate and the skirt plate (drawing items 1 and 2). It is not clear to the staff if there are additional joints between ITS SSCs that should be marked with weld symbols.

The staff requires information on the codes, standards, or other specifications for the material, welding, and weld examinations of the ITS SSCs to support its review of the structural performance of the impact limiter.

This information is required to demonstrate compliance with 10 CFR 71.31(c).

2-2 Justify and clarify the material modeling assumptions used to describe item 4, the perforated aluminum 6061-T6 impact limiter component.

Item 4 of (perforated impact limiter) on Drawing 11758, Sheet 1 is made of 6061-T6 aluminum which goes to failure (fracture) in the 9 m side drop simulation (part ID 121 in LS-DYNA) as shown below:



The material model used is material model 120 (024), or: MAT_PIECEWISE_LINEAR_PLASTICITY_(TITLE)(024).

A failure strain of 0.426 (true strain) has been specified (engineering strain of 53.1); however, this material model does not account for strain rate, triaxiality, or uniform elongation.

Reference 2.2.6 in the application, “Properties of Aluminum Alloys, Tensile, Creep, and Fatigue Data at High and Low Temperatures, ASM International, November 2006” reports a typical failure strain of only 17% (engineering strain) or a true strain of 0.157 at room temperature, which depends heavily on the product form. However, simulation results show effective strain rates greater than 5,000 in the 9 m side drop scenario.

Minimum allowable engineering failure strains for ASTM 6061-T6 are lower, approximately 8-10%, depending on the product form. Poisson’s ratio has also been set to 0.33 when it appears it should be 0.3.

Since supplied material properties of aluminum are most likely to be larger than those tabulated in ASME (i.e. yield strength) or have smaller values than those reported for elongation, it is reasonable to expect that higher loads will be observed by item 4 and thus potentially fracture under smaller ductility demands.

In addition, it has also been noted that Holtec document HI-2188068 does not report g-loads for the 9 m drop side like it does for other regulatory drops.

The applicant shall describe the condition of the package for all simulated drops that utilize strain rate, Poisson’s ratio, triaxiality, minimum allowable elongation, and both minimum and maximum ASME yield strength values in order to model Item 4, which is made from aluminum 6061-T6. The applicant shall update the calculations and simulations reported in the application, as necessary.

This information is required to demonstrate compliance with 10 CFR 71.71(c)(1), 71.73(c)(1), and 71.73(c)(3).

2-3 Perform a quasi-static testing of a mock-up of a slice of the perforated aluminum ring.

Given the computed structural performance anomalies observed in RAI 2-2 above, the staff expects that the perforated aluminum ring LS-DYNA modeling is benchmarked by quasi-static testing of a prototypical ring segment mock-up. The testing should be sufficiently representative of the perforated aluminum ring load-deformation structural performance parameters, including the predominant impact limiter loading direction and footprint size, as well as the steel backbone stiffness and its contact simulation.

Page 2.7-6 of the application, 3rd bullet, states, “Following the same approach as used in the benchmarking…The perforated aluminum ring used in version LW impact limiter design…is also characterized by the true-stress-stress-true-strain relationship of the…material model MAT_024.” The staff notes that the impact limiter stainless steel casing modeled with shell elements, in lieu of brick elements, is generally not counted for energy dissipation in mitigating the cask free drop impact effect.

As such, contrary to the statement in the application, modeling of a perforated aluminum ring with the MAT_024 material model cannot be considered similar to that of other HI-STAR impact limiters. Quasi-static testing of a prototypical ring segment mock-up is likely to provide the load-deformation relationship to correlate the LS-DYNA results with those observed in the testing.

This information is required to demonstrate compliance with 10 CFR 71.31(b) and 71.73(c)(1).

2-4 Clarify the evaluation, in Section 2.5.2 of the application, on the excessive load protection.

The application states: “The results of the calculation are summarized in Table 2.5.4. The ultimate load capacity of the trunnion is governed by the cross section of the trunnion outboard of the cask. Loss of the external shank of the trunnion under excessive load, therefore, will not cause loss of any other structural or shielding function of the HI-STAR 100MB cask.”

Table 2.5.4 lists the bending and shear stress safety factors of 27.7 and 32.0, respectively, for the solid trunnion. The bearing stress safety factor of 11.6 is reported for the hollow trunnion. Considering the smallest safety factor of 11.6, it is unclear what the “loss of the external shank” really mean with respect to the excessive load protection requirement per 71.45(b)(3).

If the trunnion assembly is to slip off the cask body under excessive load, the failure mode should clearly be presented in the application.

This information is required to demonstrate compliance with 10 CFR 71.45(b)(3).

2-5 Provide specifics of the materials used for the impact limiter.

Drawing No. 11758, sheet 1 of 3, indicates that item 3 (impact limiter material) is made of aluminum honeycomb with a range of density and crush strength properties. Supporting calculations indicate that this proprietary material is made only by Hexcel.

The specifics of the material have not been provided. Provide:

a) Exact material/product line names used to construct the impact limiter honeycomb material on the licensing drawings, including the fabricator. The product line CROSS-CORE from Hexcel’s product line is referenced in some of the calculations but this product line appears to no longer be carried by Hexcel.

b) Catalog cuts/supporting technical data sheets of material used to construct the impact limiters (density, crush strength, aluminum alloy, etc.,) that support the values used in the document HI-2188068 and simulations performed using LS-DYNA.

c) Justification for interpolating between material properties in supporting calculation document HI-2188068 (i.e., Appendix c) for a specific crush strength that Hexcel does not fabricate.

d) Justification for 9500 psi yield strength of impact limiter crush material in supporting calculation document HI-2188068 (i.e., Appendix c) and used in the simulation models. It is unclear how this value was determined and how it is applicable to the entire range of impact limiter material(s) specified on the licensing drawings.

This information is required to demonstrate compliance with 10 CFR 71.71(c)(1), 71.73(c)(1), and 71.73(c)(3).

2-6 Clarify the performance of whole parts subjected to drop and puncture tests that are made of multiple pieces with undefined weld information.

Note 6 on Sheet 1 of 3, Drawing 11758 states: “PARTS MAY BE MADE OF MULTIPLE PIECES. WELD TYPE AND STYLE TO BE DETERMINED BY FABRICATOR PROVIDED SAFETY FACTORS ARE MAINTAINED.”

It is unclear how components made in this fashion will perform for drop and puncture tests, given that material properties may not be the same as for the base materials, and may also have weaker joint details.

Provide weld design, weld dimensions/location, and calculated safety factors as compared to whole parts detailed in the safety analysis report.

This information is required to demonstrate compliance with 10 CFR 71.71(c)(7), 10 CFR 71.73(c)(1), and 10 CFR 71.73(c)(3).

2-7 Clarify the location, design, and performance of unspecified lifting features

Note 9 on Sheet 1 of 3, Drawing 11758 states:” ADDITIONAL LIFTING FEATURE MAY BE ADDED PROVIDED ALL SAFETY FACTORS ARE MAINTAINED.”

Staff is concerned that undocumented lifting features will introduce unintended forces into the package due to unspecified material, geometric singularities, inherent component weakness, redirected forces etc., with respect to package drop test performance.

Staff cannot make a regulatory finding with respect to lifting devices for a lifting feature that is not described in the safety analysis report or licensing drawings.

This information is required to demonstrate compliance with 10 CFR 71.71(c)(7), 10 CFR 71.45(c)(1), and 10 CFR 71.73(c)(3).

2-8 Clarify how vague or unspecified NITS items will affect the package performance with respect to drop tests.

Note 10 on Sheet 1 of 3, Drawing 11758 states: NOT IMPORTANT TO SAFETY(NITS) COMPONENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES AND MAY VARY. ADDITIONAL NITS COMPONENTS MAY BE ADDED.

Staff is concerned that undocumented NITS features, and poorly defined NITS items, will affect ITS components as they could introduce increased package demands due to unspecified material, geometric singularities, inherent component weakness, redirected forces etc. with respect to regulatory drop tests, and cause unintended galvanic reactions between materials.

Staff cannot make a regulatory finding with respect to the package’s drop test performance with unknown NITS features that are either poorly described or undefined in the safety analysis report or licensing drawings. The applicant shall detail this information on the licensing drawings and in the application, as appropriate.

This information is required to demonstrate compliance with 10 CFR 71.71(c)(7), 10 CFR 71.45(c)(1), and 10 CFR 71.73(c)(3).

2-9 Clarify the bolt engagement length and the surrounding tube depicted in Detail ZB on Sheet 3 of licensing Drawing 11758.

The bolt (Part 6) has an engagement length of 2 ¼ inches, but appears to be modeled as 3 inches long in the LS-DYNA drop simulations. The tube that houses this bolt appears to have no dimensions nor it is listed on the bill of materials.

Both bolt engagement and bolt tube housing affect the package's ability to retain its impact limiters during a drop. Provide this information on the licensing drawings and update any calculations/simulations as necessary.

This information is required to demonstrate compliance with 10 CFR 71.71(c)(1).and 71.73(c)(3).

CHAPTER 3 THERMAL REVIEW

3-1 Clarify and then justify the allowable temperature limits for: (a) the Parker V1289-75 and VM125-75 elastomeric containment seals, and (b) the metallic containment seals used for the HI-STAR 100MB package.

(a) Table 2.2.11a shows that the short-term temperature limits of the elastomeric seals (Parker's V1289-75 and VM125-75) are increased in Rev. 3 of the application, when compared to Rev. 2, to meet the increased temperatures for the additional margin under the HAC fire (see Table below). The applicant needs to clarify that any change in elastomeric seal temperature limits is justified and provide applicable references.

(b) Table 2.2.11b shows that the short-term minimum upper operating temperature limit of the metallic seals (190°C, ≤ 20 hours) which is lower than the short-term limit of the elastomeric seals Parker's V1289-75 and VM125-75 (270°C, ≤ 20 hours). In general, the metallic seals have a higher temperature limit than the elastomeric seals. The applicant needs to provide references (e.g., publications or material source book) to clarify the minimum upper operating temperature limits of the metallic seals.

	SAR Rev. 2 (HI-2188080)	**SAR Rev. 3** (HI-2188080)
Elastomeric seals	Parker's V1289-75 and VM125-75	Parker's V1289-75 and VM125-75
Maximum lower operating temperature limit	-30°C	-40°C
Minimum upper operating temperature limit		
Sustained	150°C	150°C
Short Term	190°C ≤ 20 hours 250°C ≤ 3 hours	270°C ≤ 20 hours

This information is required to demonstrate compliance with 10 CFR 71.51(a)(2) and 71.73(c)(4).

3-2 Clarify the thermal properties of the impact limiter Version LW used in the thermal evaluations. Specifically provide:

(a) The basis for the minimum and maximum thermal conductivities of the impact limiter Version LW upper crush material in Table 3.2.2, along with the testing results or analyses that were performed to identify these values, and show how the properties used in Report No. HI-2188066 Rev. 4 are bounding.

(b) The values of densities and heat capacities of the upper and lower crush materials used in the bounding NCT and HAC thermal evaluations, instead of citing “see impact limiter drawing in SAR Section 1.3” in Table 2.2.8, for the impact limiter upper crush material and citing “ASM [3.2.3]” in Table 3.2.1 for the impact limiter lower crush material (Aluminum 6061-T6). Also provide the basis for using these densities and heat capacities for the upper and lower crush materials in the bounding NCT and HAC thermal evaluations.

The applicant stated in Section 3.3.9 that the impact limiter Version LW consists of two types of crushable material: an upper crush material and a lower crush material (perforated Aluminum 6061-T6 lower crush material). It is not clear to the staff how the thermal properties of the impact limiter Version LW are applied to the thermal evaluations and whether the thermal properties selected for the thermal evaluation are appropriate for the bounding evaluation to ensure the temperatures of fuel cladding and packaging components, including the containment seals, are below their maximum allowable limits.

This information is required to demonstrate compliance with 10 CFR 71.71 and 71.73(c)(4).

3-3 Explain the difference between the maximum outer lid seal temperature shown in Table 3.1.3 (Report HI-2188080 Rev. 3) and the maximum outer lid seal temperature shown in Figure S.6.1 of Report HI-2188066 Rev. 4, during the HAC fire/post-fire conditions.

Table 3.1.3 of the application shows a maximum outer lid seal temperature of 233°C (451°F) for the F-32M during the HAC post-fire cooldown. However, Figure S.6.1 of Report No. HI-2188066R4 shows that the F-32M maximum outer lid seal temperature is always below 230°C (gray curve in Figure S.6.1) during the entire HAC fire, including the post-fire cooldown. The applicant needs to explain this difference between Table 3.1.3 and Figure S.6.1.

This information is required to demonstrate compliance with 10 CFR 71.51(a)(2) and 71.73(c)(4).

3-4 Provide the time variant metallic seal temperatures (temperature history) of the F-32M to verify that the metallic seals, located at the vent/drain ports, maintain their temperatures below the operation limits during the HAC fire.

Table 2.2.11b of the application shows that the metallic containment seals have the lower short-term operating temperature limits of 190°C (≤ 20 hours) and 250°C (≤ 3 hours), when compared to the short-term operating temperature limit of 270°C (≤ 20 hours) for the elastomeric containment seal, as shown in Table 2.2.11a of the application.

The applicant displayed the time variant elastomeric seal temperatures of the F-32M during the HAC fire in Figure S.6.1 of Report HI-2188066 Rev. 4. Given that thermal properties and temperature limits of the metallic seal are different from those of the elastomeric seal, the applicant needs to also provide the time variant metallic seal temperatures (temperature history) of the F-32M during the HAC fire to verify that the metallic seals at the vent/drain ports meet the short-term operating temperature limits during the HAC fire.

This information is required to demonstrate compliance with 10 CFR 71.51(a)(2) and 71.73(c)(4).

3-5 Provide an evaluation for the postulated scenario that a flame, from an HAC fire, may penetrate the perforated 6061-T6 aluminum block through its holes and reach the lid under the HAC 30-minute fire and its post-fire cooldown, or provide a justification that this postulated scenario cannot occur.

The impact limiter Version LW consists of the upper crush material and the lower crush material (perforated 6061-T6 aluminum block). The holes on the perforated 6061-T6 aluminum block are almost 2.5-inch wide and go all the way through the aluminum block (see Drawing No. 11758, sheet 2 of 3).

The flames during the HAC fire may penetrate the perforated 6061-T6 aluminum block through its holes and reach the lid (such that the flame has a direct contact with the lid). The applicant needs to evaluate whether the flame penetration could raise the PCT and the package component temperatures (e.g., seal temperatures) over the respective PCT and component design temperature limits during the HAC fire and its post-fire cooldown. Alternatively, the applicant shall provide a justification that this scenario cannot occur.

This information is required to demonstrate compliance with 10 CFR 71.51(a)(2) and 71.73(c)(4).

3-6 Provide a justification for the derivation of the Holtite rib effective thermal conductivity, when used as the radial and tangential thermal conductivities of the rib, in the thermal model.

As presented in Appendix B of Report No. HI-2188066 R4, the applicant derived the Holtite rib effective thermal conductivity using the temperature difference between the rib ID surface and the rib OD surface.

The applicant defined the derived effective thermal conductivities as a function of the rib ID surface temperatures of 200°F, 300°F, 550°F, 800°F and 1100°F, when used as the radial and tangential thermal conductivities in the thermal model.

Temperature at rib ID surface, °K (°F)	366.5 (200)	422.0 (300)	560.9 (550)	699.8 (800)	866.5 (1100)
Temperature at rib OD surface,°K (°F)	310.9 (100)	366.5 (200)	505.4 (450)	644.3 (700)	810.9 (1000)
Average value of the rib ID and OD surface temperatures (°F)	(150)	(250)	(500)	(750)	(1050)
Effective thermal conductivity (W/(m-°K)	55.14	53.18	47.44	41.84	35.15

The staff reviewed Appendix B of Report No. HI-2188066 Rev. 4 and finds that the effective thermal conductivity is calculated from the temperature difference between the rib ID surface and the rib OD surface. Therefore, it may be more appropriate and bounding to define the effective thermal conductivities (row #4 in Table) as a function of the average temperatures of the rib ID surface and the rib OD surface (150°F, 250°F, 500°F, 750°F, and 1050°F as seen at Row #3 in Table).

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Given the fact that the rib is one of the main components to transfer heat from the package, the appropriate use of the effective thermal conductivity in the thermal evaluation is important. Therefore, the applicant needs to justify whether the effective thermal conductivity (Row #4) should be defined as a function of the rib ID surface temperatures (Row #1), or as a function of the average rib ID/OD surface temperatures (Row #3) for the bounding thermal analysis.

This information is required to demonstrate compliance with 10 CFR 71.71 and 71.73(c)(4).

Chapter 5 SHIELDING REVIEW

5-1 Provide the cobalt impurity information in Table 5.2.2.

In Section 5.2.1, the applicant states "Table 5.2.2 provides the steel and Inconel masses of the design basis fuel assembly outside the active fuel zone. The table also provides the mass of the non-zircaloy parts of the grid spacers. In addition to the steel and Inconel masses, the masses of Co^{59} impurity levels are also provided." (Emphasis added.) Staff reviewed Table 5.2.2 and the cobalt impurity level is not present in the table.

This information is required to demonstrate compliance with 10 CFR 71.31(b).

5-2 Justify the 0.5 g/kg or 500 ppm Co^{59} impurity level for both steel and Inconel fuel structural hardware.

On page 5.2-2 of Revision 3 of the application, the applicant states: “Subsection 5.2.1 of HI-STAR 100 SAR indicates that the Co^{59} impurity level in steel was 800 ppm or 0.8 g/kg and in Inconel was approximately 4700 ppm or 4.7 g/kg. Since mid-1980s, major fuel vendors have reduced the Co^{59} impurity level in both Inconel and steel to less than 500 ppm or 0.5 g/kg. In the calculations performed here, a Co^{59} impurity level of 0.5 g/kg Is used for the steel and Inconel components of PWR fuel assemblies …”

Regulatory Guide 3.54 Revision 2 concludes that 0.8 g/kg was a conservative cobalt impurity assumption for Type 304 stainless steel. The guide notes that manufacturers currently (as of 2009) measured concentrations suggesting “significantly lower cobalt levels than used in the calculations for the guide.”

The applicant refers to HI-STAR 100 SAR Section 5.2.1, which used 0.8 and 4.7 g/kg for steel and Inconel, respectively. The applicant did not provide any data to support the reduction in Co^{59} impurity. The applicant also did not provide any information on a time from which the 0.5 g/kg impurity assumption would be an appropriate assumption.

This information is required to determine if the activation source calculated at 0.5 g/kg Co^{59} is still conservative for older fuel that may not meet this impurity requirement.

This information is required to demonstrate compliance with 10 CFR 71.47(b) and 71.51(a)(2).