Request for Additional Information
Holtec International
Docket No. 71-9375
HI-STAR ATB 1T Package

By letter dated February 6, 2017, Holtec International (Holtec) submitted an application for Certificate of Compliance No. 9375, Revision No. 0, for the Model No. HI-STAR ATB 1T package. By letter dated April 14, 2017, Holtec responded to a request for supplemental information (RSI) letter dated March 21, 2017. The application was accepted for review on May 10, 2017.

This request for additional information (RAI) identifies information needed by the U.S. Nuclear Regulatory Commission staff (the staff) in connection with its review of the HI-STAR ATB 1T package application to confirm whether the applicant has demonstrated compliance with regulatory requirements.

The requested information is listed by chapter number and title in the package application. NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," was used for this review.

Chapter 1 – General Information

Licensing Drawings

1-1 Indicate groove weld size that can be used interchangeably with fillet welds.

Additional note 3 on Sheet 1 of Drawing 9786 indicates in part that "fillet welds may be replaced with groove welds of equal or greater strength". Provide the size of the groove weld that will be used in place of a fillet weld in these instances since it is unclear how a weld of greater strength will be provided without such information.

This information is needed by the staff to determine compliance with 10 CFR 71.33.

1-2. Clarify the dimensions of lid spacer bars shown in the cask lid sub-assembly and how they are modeled in LS-DYNA.

Sheet 3 of 5 on Drawing 9786 indicates there are 5 evenly spacer bars with undetermined thickness and height and attachment to the closure lid (BOM 8). It is assumed that they are like BOM item 42, which is welded on one side with a ¼" fillet, although BOM 42 has different proportions. Drop and puncture simulations in LS-DYNA treats them as fully integrated into the closure lid (BOM 8). Clarify the dimensions of the lid spacer bars, their connection to the closure lid, and update LS-DYNA drop and puncture simulations for normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as needed based on their actual attachment to the lid.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

1-3 Provide additional clarifying information on the drawings of the package in Section 1.3 of the application, as described below.

Drawing 9876, Sheet 1 of 8 states that “all dimensions are in inches.” The dimensions do not match up with those described in the application, including Drawing 9786, and therefore appear to be in millimeters. The applicant needs to correct the typographical error stating that these dimensions are in inches.

Drawing 9786 and 9876 contain instances where the designation “TYP.” Is used. Clarify what this means and provide minimum dimensions for all components that are credited within the shielding evaluation. Wall thicknesses credited within the shielding evaluations cannot be “typical” and must contain minimum dimensions as these perform a safety function for radiation shielding.

Some drawings are missing dimensions of components used for shielding. Revise the drawings to include minimum dimensions of all components used for shielding, including the thicknesses of the walls of the BFA-tanks and BFA-Tank cassettes. The wall thicknesses for all 4 different BFA-tanks and BFA-Tank Cassettes need to be shown. Table 7.1.2 of the application states “representative wall thickness of the Waste Package,” as these are used as radiation shielding the components are considered important to safety and the minimum allowable dimensions must be defined.

Provide additional labeling of the drawings. Since the ATB-1T is a rectangular parallelepiped, 2-D rectangular views should clearly identify which face of the package it represents.

NUREG/CR-5502, “Engineering Drawings for 10 CFR Part 71 Package Approvals,” provides guidance for preparing drawings of transportation packages submitted in an application for approval under 10 CFR Part 71. It states that engineering drawings should have tolerances that are consistent with the package evaluation. 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). The shielding analysis should include the design drawing tolerances, which would, in this scenario, be less restrictive than the manufacturing tolerances.

This information is needed by the staff to determine compliance with 10 CFR 71.33(a).

Chapter 2 – Structural and Materials Evaluation

2-1 Clarify how strain rate criteria is applied to certain portions of lid and flange only, and how damage in these regions due to free drop will be affected by the thermal test described under HAC.

The last sentence of ASME Section FF-1110 states: “*These strain-based acceptance criteria are not allowed to be used in instances where the resulting deformations could result in a breach of the containment.*”

The HI STAR ATB 1T parts have been partitioned arbitrarily into zones (not discussed by ASME) which indicate when certain criteria will apply. Specifically, the application states that Zone A is where ASME strain based criteria (non-mandatory appendices EE and FF) will be applied, while Zone C is where high strains are expected but away from Zone A. The application describes Zone C as one that: *"If a crack were to develop in Zone C as a result of the high deformation levels, it would not pose a threat to the containment boundary for the following reasons. The extended portion of the top flange is not a pressure retaining component, and therefore a thruwall crack in this region of the top flange cannot produce a leak in the containment cavity. For the closure lid, if a crack were to develop in Zone C as the result of a drop event, it would be arrested by the machined slots in the lid for the[closure lid locking system] CLLS before reaching the containment boundary.*"

However, Figure 2.1.1 indicates that the flange and lid are part of the pressure retaining boundary. It is unclear how machined slots will arrest any cracks present in the material. Cracks have been known to be arrested by mechanical fasteners such as bolts and rivets due to localized compression, or by drilled holes at crack tips. However, none of these cases are applicable to the HI STAR ATB 1T package. Additionally, there has not been any consideration to a thermal scenario described under HAC, where the pressure in the containment boundary is expected to increase, potentially forcing any cracks in the material located in Zone C post free drop to "open up" and drive them further into Zone A.

Clarify:

a) How the flange is not part of pressure retaining boundary when it is according to Figure 2.1.1 of the application, and Sheet 1 of Licensing Drawing 9786,
b) What criteria are used to specify Zone C and A areas (these zones appear to be arbitrarily assigned), and what maximum strains and/or cracks may exist at this interface,
c) How cracks/strains in Zone C will be affected by an additional increase in pressure due to the fire scenario of HAC.

This information is needed by the staff to determine compliance with 10 CFR 71.73(c)(1) and 71.73(c)(4).

2-2 Clarify the dimensions of the trunnion keeper plate (BOM item 34) and the trunnion (BOM item 19).

Lifting calculations contained in document HI-2177540R0 indicate that the trunnion keeper plate length is 0.25in; however, there are no dimensions of this part on the licensing drawings. While the trunnion keeper plate is NITS, it does affect the overall length of the trunnion (ITS) since the axial length of the trunnion is specified relative to the trunnion keeper plate.

Additionally, lifting calculations do not appear to consider the trunnion keeper plate's protrusion into the trunnion. As drawn, it appears that the entire cross section of the trunnion cannot be used for lifting calculations as relied upon in document HI-2177540R0 due to the trunnions keeper plate location.

Provide the axial length of the trunnion and trunnion keeper plate dimensions on the licensing drawings and revise the lifting calculations, as necessary, for a reduced available cross-section due to the trunnion keeper plate.

This information is needed by the staff to determine compliance with 10 CFR 71.45.

2-3 Clarify or revise the number of trunnions used in lifting calculations.

Lifting calculations contained in document HI-2177540R0 indicate that 8 trunnions will be used for lifting in Section 6.2.1. However, the preceding sections of those calculations (Sections 2.5.1.1 and 8.1.3.1 of the application) indicate that only 4 trunnions are actively in use during lifting operations.

Verify and/or revise the lifting calculations as necessary, as it appears that the bearing stress values would be exceeded if only 4 trunnions, rather than 8, were to be used.

This information is needed by the staff to determine compliance with 10 CFR 71.45.

2-4 Clarify the triaxiality values used to predict material failure in LS-DYNA simulations.

Triaxiality values used in material model 224 (Tabulated Johnson-Cook) In LS-DYNA appear to be inputted incorrectly. As specified, failure strains do not occur more readily with increasingly positive triaxiality, while failure strains due to compressive behavior do appear to occur more readily with increasingly negative triaxiality. Both the trend and values of specified triaxiality appear to be incorrect relative to the values and guidance in the non-mandatory appendix of Section EE-1150.

Clarify these values and/or update all LS-DYNA drop and puncture simulations for both normal and accident conditions since element failure can potentially result in breaches in the containment boundary due to material failure.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-5 Justify the dimensions and placement of the puncture bar used for the puncture test for HAC conditions along with the initial state of the package.

Title Code 10 CFR 71.73(a) indicates that the same specimen subjected to the free drop test, is to be subjected to the puncture test. For the LS-DYNA simulation titled "1m-CGOC Puncture", the starting condition of the specimen is one that appears to have been subjected to a 9m drop on its center of gravity over corner (CGOC). However, an "interrogation" of the model indicates that there is no initial plastic strain anywhere in the package prior to the simulated the puncture test. Since the intent of this sequence of drops is to properly account for cumulative damage, it appears that that package could have indeed more damages than observed.

In addition, it appears that the puncture bar is not directed at the most damaged portion of the specimen. That is, the puncture bar should be directed to strike the breached portion of the outer bottom plate (BOM Item 1) where the underlying weld and intermediate shell are exposed. The puncture bar itself should also be shortened to the minimum length of 8 inches as described in the regulations for maximum impact. As modeled, the puncture bar is 30 inches long and is redirecting potential forces and energy away from the package as evidenced by excessive deformation in the puncture bar itself. For the 1m-CGOC puncture simulation, update:

a) The initial starting plastic strains from the previous 9m CGOC drop,
b) Corrected puncture bar placement,
c) Shortened puncture bar length,

and describe the state of the package with respect to containment and dose rates.

This information is needed by the staff to determine compliance with 10 CFR 71.73(c)(1), 71.73(c)(3), and 71.51(a)(2).

2-6 Clarify the dimensions and the modeled properties of the cask wedge blocks depicted on licensing drawings used in LS-DYNA simulations for both the prototype and ATB 1T. Sheet 2 of Drawing 9786 of the ATB 1T depicts cask wedge blocks (BOM 11) in relationship to the top flange (BOM 2) under the view “closure lid wedge system”. It appears that the cask wedge blocks are tapered 4^{o} and forced against an equally tapered 4^{o} closure lid locking wedge (BOM 9 and 10).

According to Section 2.3 of the application, shims will also be installed against the cask wedge blocks. This similarly applies to the prototype as well, as shims were used at the location of the wedge blocks. Since the cask wedge blocks help maintain a positive closure on the seals of the package:

a) Describe why wedge blocks (BOM 9 and 10) are not modeled with a 4^{o} taper.

b) Provide the compressive stress (sealing force) expected on the seals (BOM 7) and the sealing surface of the flange (BOM 2) when the lid (BOM 8) is fully engaged by closure lid locking wedges (BOM 9 and 10). The expected compressive force (if any) should be incorporated into LS-DYNA simulations, supported by calculation, and tractable with respect to an installation procedure.

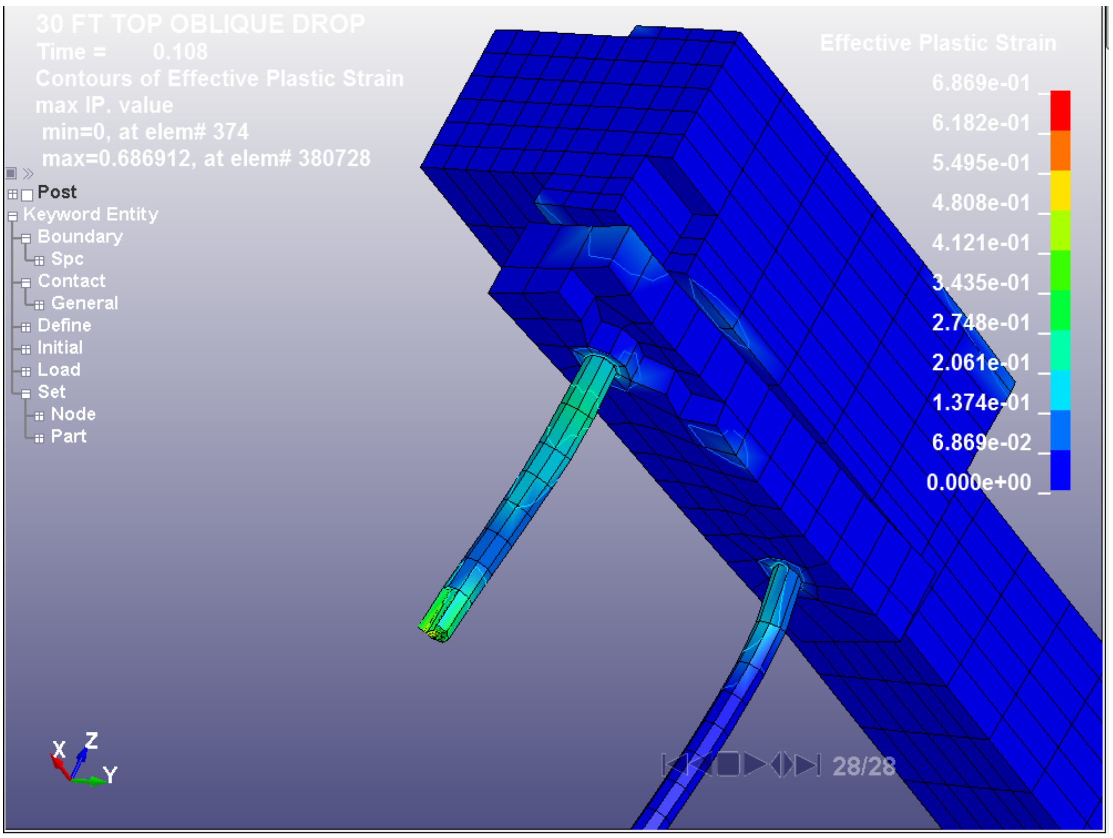
It is noted that the procedure used to ensure this sealing force is key to keeping the containment boundary intact and should be deployed reliably when operating the package.

c) Describe why shims (currently un-dimensioned or not specified material-wise) are not incorporated into the HI-STAR ATB 1T and prototype LS-DYNA models. Shims are key to maintaining closure rather than being incidental to fabrication. Shims and wedge blocks were known to have become loose during prototype drop testing and should be modeled as such for puncture and drop simulations for NCT and HAC.

d) Describe how cask wedge block securing bolts (BOM 12) are connected to the cask wedge blocks and/or the flange (BOM 2). It appears that the wedge blocks are directly attached to the securing bolts rather than just having a surface to surface contact. As modeled, a large, unrealistic tensile force would be needed to dislodge the wedge blocks from the bolts (via bolt failure). The bolts should be modeled per actual installation.

e) Describe why a contact surface such as eroding-surface-to-surface was not specified in LS-DYNA between the flange (BOM 2), closure lid locking wedges (BOM 9 and 10), and the cask wedge blocks. Such a surface currently exists between the cask wedge blocks (BOM 11) and the cask wedge securing bolts (BOM 12).

It was noted that both the wedge blocks (BOM 11), the closure lid locking wedges (BOM 9 and 10), and the wedge block securing bolts (BOM 12) undergo element erosion (material failure) depicted as missing "cubes" in the image below (30 ft oblique drop shown).



Update all LS-DYNA simulations for both the prototype and ATB 1T as necessary along with the results in the Safety Analysis Report (SAR) and benchmarking work.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-7 Clarify why strain rate and triaxiality effects were not considered in modelling the material behavior of those components made with SB637-N07718 with respect to drop and puncture simulations for HAC.

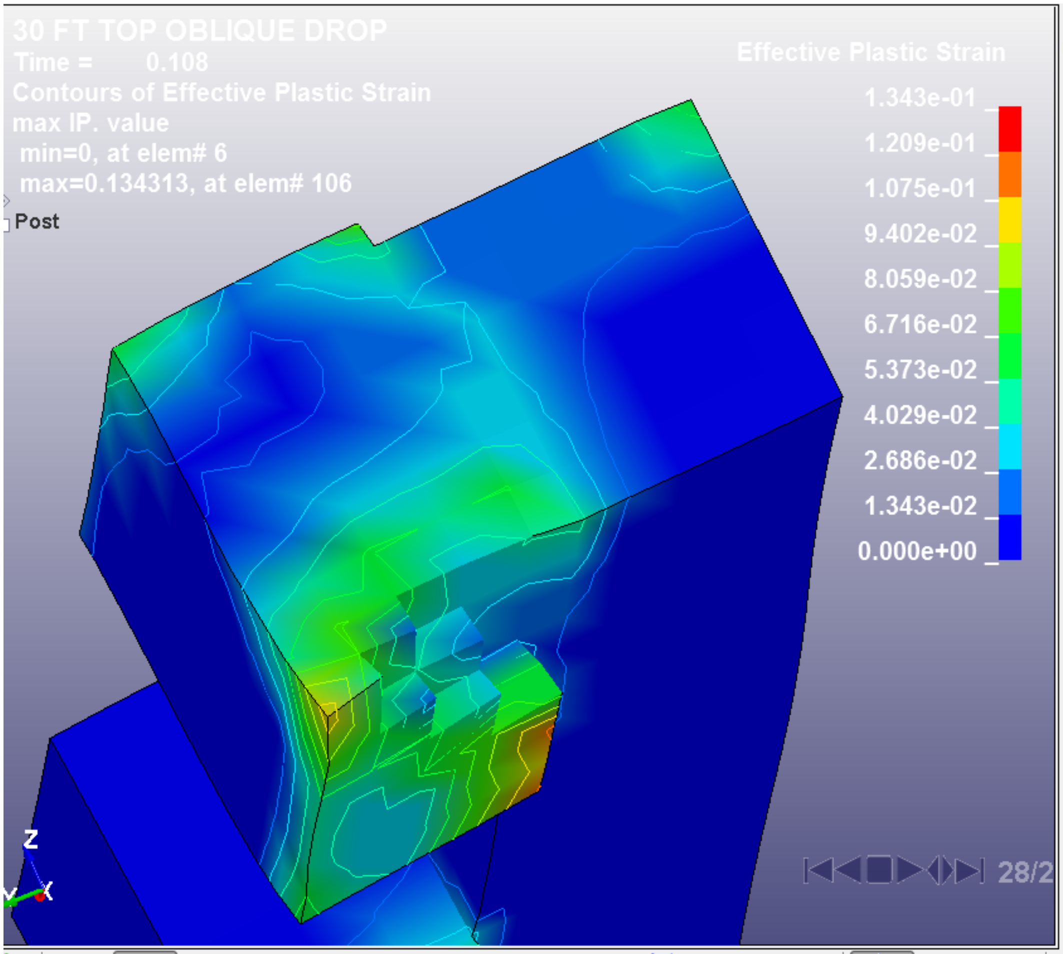
Several ITS components such as the closure lid locking wedges, cask wedge blocks, and locking wedge pins are made with SB637-N07718 material. At least one drop simulation such as the 30 ft oblique drop, depicts element erosion (material failure) for both wedge blocks (BOM 11), closure lid locking wedges (BOM 9 and 10), and cask wedge securing bolts (BOM 12) as shown in the image for RAI 11. Without incorporating triaxiality and strain rate effects, additional portions of these parts could be failing, potentially jeopardizing the closure lid's ability to remain secure.

Clarify why these material phenomena were excluded from the model and/or update drop and puncture simulations in LS-DYNA.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-8 Clarify and justify the acceptance criteria used for the closure lid locking mechanisms and how this part is modeled in LS-DYNA.

Section 2.1.2.2 of the application states that the acceptance criteria for the closure lid locking mechanism is such that it should not undergo gross yielding. For at least one LS-DYNA simulation, the 30 ft oblique drop appears to depict gross yielding of the closure lid locking wedge along with some material failure. The missing material is depicted below:



Gross yielding is assumed here to have occurred because a plane can be passed through the end of CLLS, and encounter effective plastic strain throughout that plane.

Clarify how this acceptance criteria is met in this instance and why the criteria is valid. It could be argued that the CLLS can undergo partial inelastic yielding (not gross) and cause a breach in containment. For instance, one face of the CLLS could suffer uniform material failure allowing the lid to become loose.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-9 Clarify the parameters used to model concrete in LS-DYNA.

Drop test simulations of the prototype in LS-DYNA use material model 16 (pseudo tensor) for representing the concrete target as part of benchmarking. However, it is unclear how the parameters used in this material model represent the actual concrete properties of the drop test site. Update the benchmarking report as necessary.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-10 Clarify the criteria used to terminate drop test simulations in LS-DYNA.

With the exception of the oblique drop test, all puncture, 0.3 m, and 9 m drop tests simulated in LS-DYNA terminate prior to a secondary impact of the package with the target.

Based on the Sandia test report, the prototype package managed to rebound 20 inches after the primary impact, and caused significant permanent deformation after the 30-ft CGOC drop due to the secondary impact. An examination of the kinetic energy in LS-DYNA for this scenario indicates that around 5% of the initial kinetic energy remains after the first impact of the package. Similar energy ratios can be found for other 30 ft drop simulations.

Given that the simulated bottom end drop for the 1-ft NCT drop simulation of the package was enough for the full scale package to experience significant inelastic deformation in the landing around the seals, describe the state of the package post primary impact of the package for NCT and HAC drop test simulations and the criteria under which the package will be judged to have come to rest.

This information is needed by the staff to determine compliance with 10 CFR71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-11 Justify the large amounts of hour glassing energy found in parts for the prototype and the HI-STAR ATB 1T package during drop and puncture LS-DYNA simulations.

Typically, it is desired that hour glassing energy be as small as possible (under 10%) relative to internal energy (energy ratio) as large amounts of hour glassing energy lead to inaccurate solutions such as unrealistic deformations and physical behavior. In the case of the closure lid locking mechanism (Part 17 of the prototype), hour glassing energy reaches 200% of the internal energy during the course of the simulation when examined at a part by part basis for the puncture simulation of the prototype. This part also experiences hour glassing energy of 50% of the internal energy for the CGOC 30 ft drop of the prototype. For the 30-ft bottom end drop, the locking pins were found to have as much as 40% energy ratio while the removable wedges were found to have a 15% ratio. This behavior was also exhibited in other simulations and other components such as welds and crush bars for both the prototype and the ATB 1T.

Verify that this behavior is not occurring for both other parts and other LS-DYNA simulations. Update the application and the benchmarking report, as necessary.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-12 Justify the approach used to model welds for both the HI-STAR ATB 1T package and the prototype in LS-DYNA for free drop and puncture simulations for NCT and HAC.

LS-DYNA simulations of the HI-STAR ATB 1T package and of the prototype for both NCT and HAC drop simulations depict “horizontal welds”, such as the one located between the outer bottom dose blocker plate (BOM 13) and the outer long dose blocker plate (BOM 15). This full penetration weld has been modeled as being rectangular in cross section that is 0.86 inches thick. The licensing drawings indicate that a triangular shaped weld would be present at this location and is about 3 ¾" thick due to plate preparation (45^o bevel) not including the heat affected zone. For both the HI-STAR ATB 1T and the prototype, clarify:

a) Why the physical dimensions of the welds modeled are so different than from the licensing drawings,

b) How the heat affected zone is incorporated into the modeling of these welds,

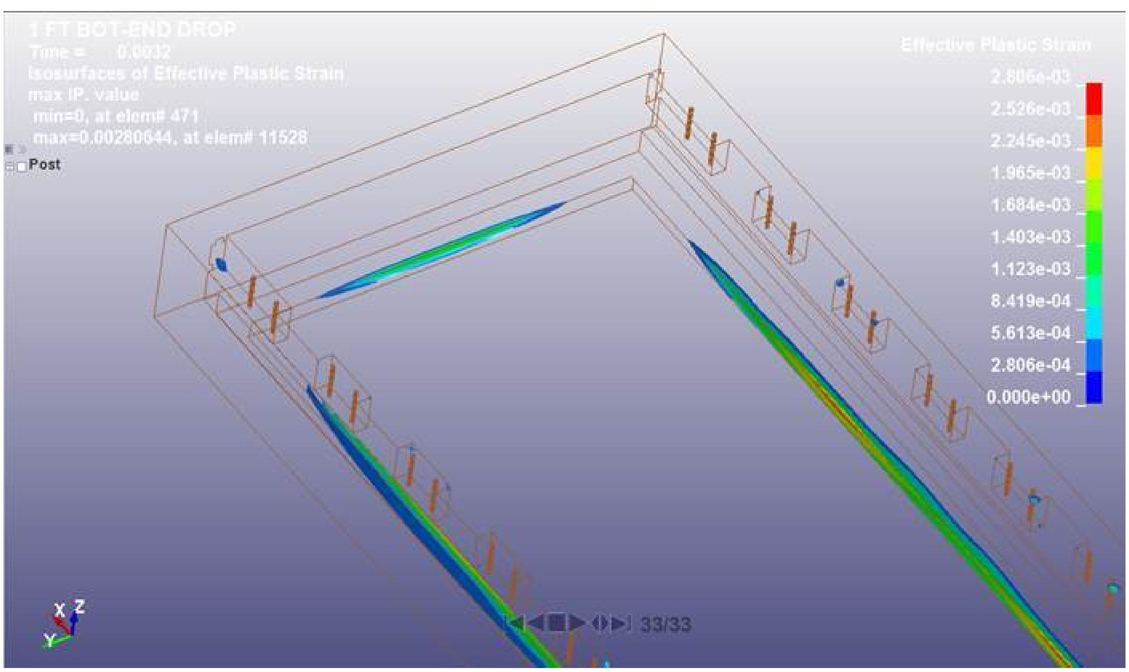
c) Why some horizontal welds, and all "vertical" welds have been excluded from both the prototype and ATB 1T, such as the weld between the outer long dose blocker plate (BOM 15) and the outer short dose blocker plate (BOM 14).

Update the weld modeling as necessary for both the prototype and the HI-STAR ATB 1T with respect to free drop and puncture LS-DYNA simulations. Ensure that both the application and the benchmarking report reflect any such changes.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-13 Verify the modeling of the top flange landing and package contents.

Page 2-8 of the application mentions that strain-based criteria cannot be applied to the landing area of the top flange (BOM 2) and of the closure lid (classified as Zone B). LS-DYNA simulations for both the bottom end 1 ft drop (NCT) and 30 ft bottom end drop (HAC) report inelastic deformations around the flange landing as depicted below (1 ft bottom end drop shown):



The flange landing in LS-DYNA has been modeled as 3.125" wide, where in the licensing drawings the landing is depicted as being only 2.5" wide. It is expected that, if a value of 2.5" had been used, higher degrees of inelastic deformation would have been reported by LS-DYNA.

In addition, higher strains may exist for HAC conditions as a result of rigid body assumptions of the contents at the flange. Specifically, the closure lid is unable to fully flex during the simulation due to contact with the contents, resulting in excess forces being transferred through the contents rather than the landing where the seals are located. The applicant shall:

a) Update LS-DYNA puncture and free drop model with regards to flange dimensions,

b) Describe the seal/flange landing performance as a function of rigid body assumptions.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

2-14 Confirm that stress limits within the lid of the ATB 1T do not exceed the values set forth by ASME for the 1-ft bottom end drop simulation for NCT conditions.

Section 2.1.2.2 of the application indicates that stresses within the lid are not to exceed ASME Section III NB values for NCT. This criteria implies that stress intensity values should remain elastic.

However, for the LS-DYNA simulation of the 1-ft bottom end drop, the closure lid (BOM 8) undergoes permanent inelastic deformation indicating that material has yielded (stress of 47 ksi according to effective Von-Mises option in LS-DYNA).
Confirm that this, and other containment boundary components, does not exceed stress intensity values according to ASME Section III NB for all NCT drop and penetration simulations nor observe plastic strain values.

In addition, clarify how stress values reported by LS-DYNA are used to compute and compare to ASME values as it is not apparent in the application how such values are determined. For instance, Table 2.6.2 of the application reports primary bending stress intensity values, but it is unclear how these values were determined based on LS-DYNA output values.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7),

2-15 Clarify how whole parts that are expected to experience inelastic deformations will perform when welded from multiple pieces under NCT and HAC drop and puncture tests.

Flag note 6 on Sheet 1 of 5, Drawing 9786, indicates that whole parts may be comprised of multiple pieces joined by full penetration welds. It is unclear how components made in this fashion will perform for drop and puncture tests at welded areas where material properties are not the same as base materials.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

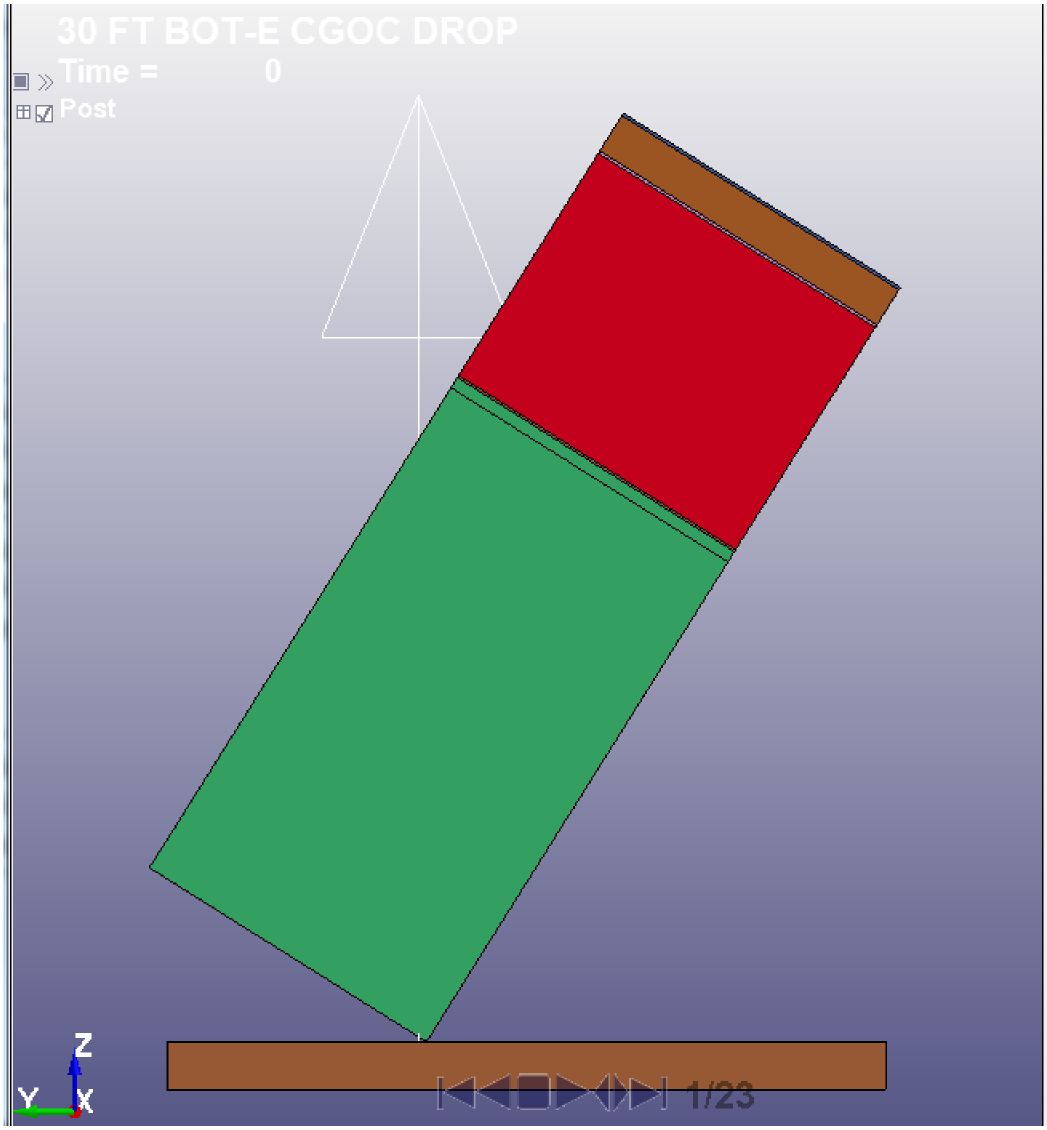
2-16 Verify that the HI-STAR ATB 1T orientation was correct when conducting CGOC simulations in LS-DYNA for NCT and HAC.

The HI-STAR ATB 1T center of gravity is located relatively close to its geometric center. An arrow drawn normal to the target and close to the point of impact should pass through the center of gravity. It is expected that this fictitious arrow would pass through the center of gravity and close to the opposing corner of the package.

It appears that this may not be the case according to the picture below where the package is seen to be leaning too far to the right from the arrow.

Verify that the package orientation for the CGOC simulation is correct.

Update all drop/puncture LS-DYNA simulations for the HI-STAR ATB 1T for NCT and HAC conditions as appropriate.



This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(7), and 71.73(c)(1).

2-17 Describe the condition of the HI-STAR ATB 1T as a result of cumulative damage resulting from the drop test and the fire test for HAC conditions.

Section 2.7.3 of the application describes thermal stresses as a result of the fire test. However, this section does not provide details regarding the structural integrity of the containment as a result of increased internal pressure due to the HAC fire test.

Describe the condition of the package in this regard by updating the application, while also noting that the package is initially damaged from a previous drop or puncture test.

This information is needed by the staff to determine compliance with 10 CFR 71.73(a) and 71.73(c)(4).

2-18 Describe the specific test methods, test conditions, and acceptance criteria that will be used to qualify the containment seal, Item 7, elastomeric, sheet 1 of 5 on drawing 9786 to meet the critical characteristics provided in Table 2.2.2 of the application.

Table 2.1.2 of the application states that the non-code seals and gaskets will be procured with manufacturer's catalog and test data. The staff note that the properties of elastomers can vary, depending on their processing and chemical composition.

The staff require information on the specific qualification tests or standards used, test conditions, and the acceptance criteria for the test results to complete its review of the capability of the seal and gaskets to meet their containment function under normal conditions of transport and hypothetical accident conditions.

This information is needed by the staff to determine compliance with the requirements of 10 CFR 71.31(c).

2-19 Define what is meant by "non-code" welds performed on the HI-STAR ATB 1T transportation packaging materials/components and define an equivalent weld procedure.

Section 2.2.3 of the application states that all non-Code welds will be made using weld procedures that meet ASME Section IX, AWS D1.1, D.1.2 or equivalent. It's unclear to the staff whether "non-Code welds" refers to the component design, weld procedure, or both. Also, clarify, both in the application and on the licensing drawings, the criteria to determine what could be an equivalent procedure. The criteria should specify the minimum critical characteristics equivalent to that of weld procedures from ASME and/or AWS national standards.

This information is needed by the staff to determine compliance with 10 CFR 71.31(c).

2-20 Clarify, both in the application and on the licensing drawings, the required materials properties of ITS items that have a generic material designation (e.g., steel, aluminum).

Item 19, steel, trunnion solid shaft, ITS, structural, and Item 37, aluminum, lid spacer, ITS, structural, sheet 1 of 5 on drawing 9786 of the application and flag notes/remarks 4 and 5, respectively, provide no or limited mechanical properties. In addition, various items, steel (various descriptions)/bolt(s), ITS, sheet 1 thru 8 of 8 on drawing 9876 of the application and flag note/remark 1 provide examples of standards, limited mechanical properties and none for the bolts.

The materials of construction for all ITS components should be described with sufficient detail to allow the staff to perform a technical review, including the minimum yield strength, tensile strength, and elongation (either by citing a specific material standard/grade or by providing the minimum material properties). The criteria should also describe how material fracture toughness or stress-rupture criteria will be met, if applicable to the product form.

This information is required by the staff to determine compliance with 10 CFR 71.31(c).

2-21 Define what “equal” mechanical properties may be substituted for use in the HI-STAR ATB 1T transportation packaging materials/components.

Note E, sheet 1 of 5, drawing 9786 states that the ASME and/or ASTM designation(s) of each material type specified herein is intended to fix its chemical and metallurgical attributes, not its raw material product form (viz. plate or forging, seamless or welded tube, etc.). Alternate product forms having the same chemical designation and equal mechanical properties may be substituted by the manufacturer. Alternate material types shall be tested in accordance with the applicable ASME code requirements for the product type.

Clarify, both in the application and/or on the licensing drawings, the criteria to determine what could be an "equal" material in lieu of those materials grades originally called for in the application. The criteria should specify the minimum yield strength, tensile strength, elongation, reduction of area, fracture toughness, and/or stress-rupture criteria (as applicable to each referenced standard in the drawings).

This information is required by the staff to determine compliance with 10 CFR 71.31(c).

Chapter 3 – Thermal Evaluation

3-1 Clarify the bounding heat load distribution for the NCT and HAC thermal analyses so that a review of maximum package temperatures can be performed.

Page 3-19 appears to indicate that maximum temperatures are found for the concentrated heat load distribution. However, page 3-18 states that the uniform heat load distribution is the limiting loading scenario for the license basis model. The thermal analyses should be based on the bounding heat load distribution.

This information is required by the staff to determine compliance with 10 CFR 71.33, 71.35(a).

3-2 Clarify the bounding condition, related to gaps, for the NCT and HAC thermal analyses so that a review of maximum package temperatures can be performed.

Page 3-19 bottom appears to state that temperatures without gaps are higher than a model with gaps. This is inconsistent with Table 3.5.5 which indicates that a package with larger thermal resistances, such as gaps, result in larger temperatures.

This information is required by the staff to determine compliance with 10 CFR 71.33, and 71.35(a).

3-3 Provide the .cas and .dat files for the bounding NCT condition and the .cas and .dat files for the post-fire HAC analyses.

Confirm that the .cas and .dat files provided are for the bounding NCT condition (see first thermal RAI above). In addition, it appears that the .cas and .dat files for the post-fire HAC condition were not provided and so a review could not be performed.

This information is required by the staff to determine compliance with 10 CFR 71.33, and 71.35(a).

3-4 Provide the residuals and energy balances for the NCT and HAC thermal analyses.

The residuals and energy balances for the NCT and HAC thermal analyses were not provided and so a review of the code convergence could not be performed.

This information is required by the staff to determine compliance with 10 CFR 71.33, and 71.35(a).

3-5 Clarify the 0.6 surface absorptivity value reported in Table 3.4.1, especially during the 30 minute fire.

Section 3.4.2 mentions a “unit absorptivity” during the fire. However, Table 3.4.1 indicates a 0.6 surface absorptivity value during the 30-minute fire, whereas 10 CFR 71.73(c)(4) specifies that the value must be either the value which the package may be expected to possess or 0.8, whichever is greater. There was no justification for the lower absorptivity. In addition, justify the 0.6 value after the fire, considering the potential for soot.

This information is required by the staff to determine compliance with 10 CFR 71.33, and 71.73.

3-6 Clarify the external convection heat transfer that occurs after the 30-minute fire.

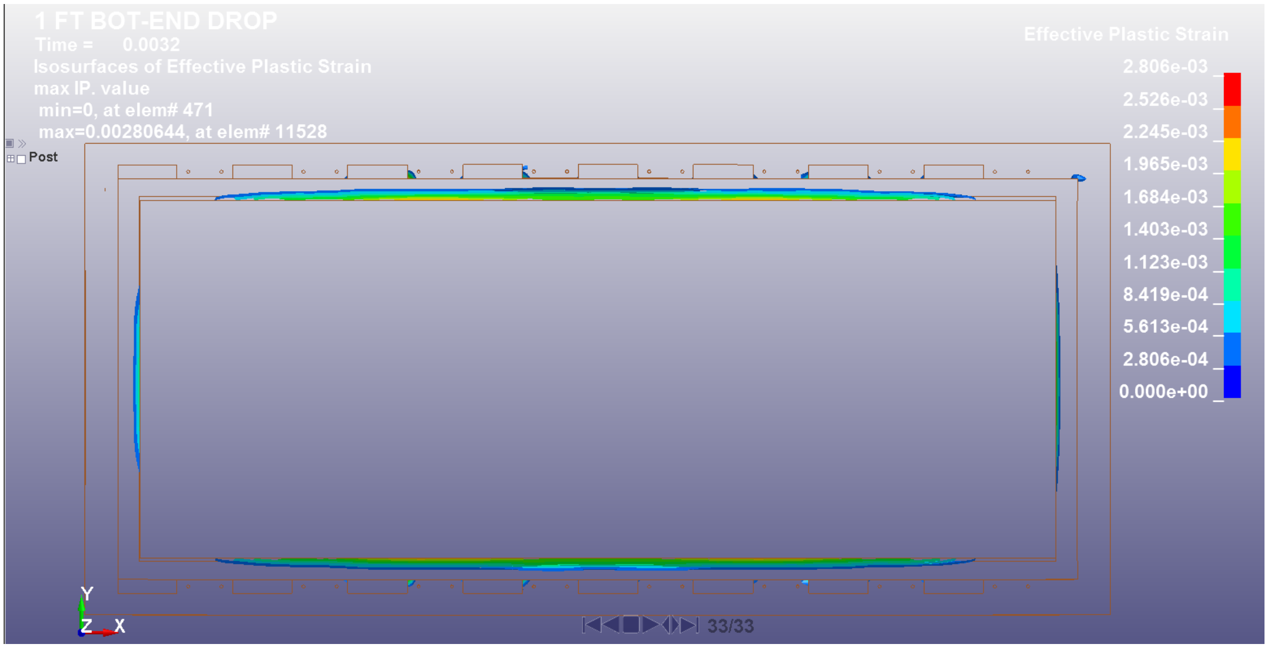
There was limited discussion of the heat transfer that occurs after the 30-minute fire and during the 1.5 hour cooldown; thus, a review could not be performed.

This information is required by the staff to determine compliance with 10 CFR 71.33, and 71.73(c)(4).

Chapter 4 Containment Evaluation

4-1 Demonstrate that the package will maintain containment under NCT and HAC tests.

An evaluation of the structural analyses shows inelastic deformation of the landing. There is no demonstration that the seal, which rests on the landing, would maintain containment after undergoing the NCT and HAC tests. The Figure below is at NCT drop; strains are greater for HAC.



This information is required by the staff to determine compliance with 10 CFR 71.51(a), 71.71(c)(7), 71.73(c)(1).

4-2 Demonstrate the applicability of the FKM fluoroelastomer seal's -26ºC to 204ºC allowable temperature range and specify the seal's performance at cold conditions, as noted in 10 CFR 71.71(c).

a) A vendor data sheet or document specifying the seals allowable temperature range was not provided and, therefore, an evaluation could not be performed.

b) Page 3-19 does not address that the cold NCT conditions (i.e., -40ºC) is beyond the -26ºC allowable seal temperature range described in Table 2.2.2.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(4), 71.71(c).

4-3 Justify the performance of the seals, including the critical characteristics of the cask containment seals specified in Table 2.2.2.

a) The table lists a 20% maximum permissible compression set at 175ºC for 70 hours and a minimum useful springback of 1.8 mm. The performance of the seals at different temperatures, such as at cold normal conditions of transport and for the thermal hypothetical accident condition was not provided.

b) Provide the calculation that justifies the 10.5 N/cm minimum force to maintain sealing at hot and cold normal conditions of transport and for the thermal hypothetical accident condition.

c) DWG 9786 sheet 5 of 5 appears to show the inside radius of the seal abutting (or extending beyond) the ledge at the four corners. Demonstrate that there is adequate seal/lid contact and that this design performs at NCT and HAC conditions.

d) Demonstrate that the package's containment boundary seal can withstand the external water pressure of the HAC immersion test. It is not certain from the analysis that the O-ring groove/gland is designed for external pressure. Likewise, there was no discussion as to whether CLLS components prevent external pressure from reaching the seal (i.e., are watertight).

e) Table 3.1.2 indicates that the cask closure lid seal temperatures of approximately 300º C are greater than the 204º C maximum allowable temperature provided in Table 2.2.2. Provide justification that supports the short term 310ºC operating temperature limit and clarify the meaning of the 100ºC upper temperature limit.

f) Provide documentation that justifies the helium permeability rates listed in Table 2.2.2.

This information is required by the staff to determine compliance with 10 CFR 71.33, and 71.51(a).

4-4 Justify that the surface activity considered in the containment analysis represents, or is bounding, of the content that would be placed within the package.

Section 4.4.1 states that the surface activity considered in the analysis is "representative of typical radioactive inventories expected" and that these were reported in Reference 4.4.1. However, Reference 4.4.1 is a characterization of "typical" surface activities, whereas the analyses should represent actual, or bounding, surface activities to ensure containment criteria are met.

This information is required by the staff to determine compliance with 10 CFR 71.51(a).

4-5 Clarify that the O-ring dimensions will be sized for the seal groove/gland dimensions provided in drawing 9786 sheet 2 of 5.

The seal groove dimensions were provided in the drawing as a result of RSI 4-2. Recognizing that the O-ring and the seal groove/gland are, together, an engineered system, it is important to specify in the SAR that the O-ring is designed for the seal groove provided in the drawings.

This information is required by the staff to determine compliance with 10 CFR and 71.33(a)(4).

Chapter 5 Shielding Evaluation

5-1 Clarify if the contents include any other radioactive materials other than activated stainless steel or activated Inconel 718.

The applicant performed source term calculations in Appendix 5.A for activated stainless steel and Inconel 718. The contents description in Section 1.2.2 of the application does not limit the radioactive contents to activated stainless steel and Inconel 718 and includes examples of contents that could consist of other materials. For example, metallic waste filters could have "ceramic mesh screens" and CRUD.

The applicant needs to clarify if it is requesting shipment for other radioactive materials and, if so, specifically (i) state what these contents are, (ii) include appropriate contents specifications, and (iii) provide analyses demonstrating that the HI-STAR ATB-1T package's shielding design is sufficient to meet regulatory dose rate limits for these contents.

This information is needed by the staff to determine compliance with 10 CFR 71.47(b)(1), 71.47(b)(2), 71.47(b)(3), and 71.51(a)(2).

5-2 Provide additional information on the neutron flux used to perform the activation analysis.

In Appendix 5.A, the applicant performed an evaluation to calculate the relative amounts of radioisotopes generated by activating stainless steel and Inconel 718. The applicant states that "The calculations are performed by irradiating 1 kg of stainless steel or 1 kg of Inconel 718 using the neutron flux calculated in SAS2H for the fuel assembly described in Reference [5.A.2]."

Reference [5.A.2] is the reference for the Model No. HI-STAR 80 package (Docket No. 71-9374). The HI-STAR 80 application consists of many different fuel assemblies irradiated under many different conditions. The staff requests that the applicant (i) provide additional information on the neutron flux used to activate the Inconel 718 and stainless steel and (ii) justify that it is bounding for determining the radioisotopes generated by neutron activation.

This information is needed by the staff to determine compliance with 10 CFR 71.47(b)(1), 71.47(b)(2), 71.47(b)(3), and 71.51(a)(2).

5-3 State and justify the geometry of the modeled contents, and modify the analyses, as necessary, to account for all possible geometries of the contents within the package.

The applicant does not specify the geometry used to model the contents for external dose rate calculations. Based on staff's estimates, the interior volume of the package is larger than that of the contents specified in Table 7.1.2 of the application at full density stainless steel. Therefore, to specify full density contents would leave space within the cask interior. The applicant needs to state the geometry it assumed for the contents and justify that it is conservative.

For example, contents modeled as shifted towards the side of the container would be more conservative as this minimizes space between the contents and the detector; also, compressing the contents concentrates the source term. In addition, external dose rates could be different if the volume of the source was concentrated at the top, short side, long side or bottom of the package.

The applicant needs to justify that the geometry and location of the source selected within the external dose rate analyses produce bounding external dose rates. The applicant needs to address any differences in the geometry that result from NCT and

HAC and address those differences within the analysis model as well as justify that it is appropriate.

This information is needed by the staff to determine compliance with 10 CFR 71.47(b)(1), 71.47(b)(2), 71.47(b)(3), and 71.51(a)(2).

5-4 Justify the assumption of uniform source distribution and modify the analyses, as necessary, to account for non-uniform sources.

Section 5.4.1 states: “The ^{60}Co source in the waste content is assumed as uniformly distributed over the appropriate regions.” The applicant needs to clarify what is meant by “appropriate regions.” The staff finds that uniformly distributing the ^{60}Co over the entire volume of the contents may not necessarily be representative of contents described in Section 1.2.2 of the application as contents may not be activated uniformly.

An activated object may be more activated near the surface and the central portions of the item may not be providing self-shielding. Uniform source distribution also does not account for the possibility of source relocation due to reconfiguration of contents during transport or removable source terms such as CRUD.

The applicant needs to discuss: (i) how it ensures the user loads contents with a ^{60}Co distribution that is bounded by the assumed distribution within the analysis and (ii) include these restrictions within the operating procedures in Chapter 7 of the application. These procedures need to ensure there is no hot spot or areas of very high activity and ensure the distribution of contents is controlled during loading and transport.

This information is needed by the staff to determine compliance with 10 CFR 71.47(b)(1), 71.47(b)(2), 71.47(b)(3), and 71.51(a)(2).

5-5 Justify the assumption that the contents remain within the BTC and BFA-tanks for the external dose rate analysis under HAC.

For the hypothetical accident analysis, the applicant assumes that the BFA-tank welds fail and that there is a gap between all BFA-tank walls. The applicant assumes that the BTC tie rods fail and that the BTC top and bottom plates would relocate. The applicant states that the bounding case would be the BFA-200 tank since this plate has the largest thickness of all BTC top and bottom plates (150 mm), and the BFA-200 tanks contain waste with the highest activity.

The applicant evaluated a drop on the top of the cask as this would cause the bottom plate to relocate. The applicant assumed the plate would rotate 45 degrees and expose a section of the contents approximately 300 mm wide. The applicant modeled this by ignoring the rotation and creating a 300 mm missing section of the bottom plate. The applicant assumed that the missing area is filled with contents at the maximum specific activity.

The dimensions of the contents are not specified and the integrity of the contents is unknown. CRUD and loose contamination could also relocate during HAC. Therefore, the staff does not have enough information to determine that the contents would not leave the BTC and relocate to the outside of the BTC and BFA-tank shield walls. The applicant needs to justify the assumption that the contents remain within the BTC and BFA-tanks under HAC.

This information is needed by the staff to determine compliance with 10 CFR 71.51(a)(2).

5-6 Justify that stainless steel as a self-shielding material is bounding for Inconel 718 or any other contents (see RAI 5-1).

The applicant states in Sections 5.3.1.2.1 and 5.3.1.3 of the application that it modeled the contents as full density stainless steel to represent the self-shielding. The applicant states that the content will be activated stainless steel or Inconel 718. The applicant needs to provide justification that modeling stainless steel is equivalent or more conservative than Inconel 718 or any other contents (see RAI 5-1).

This information is needed by the staff to determine compliance with 10 CFR 71.47(b)(1), 71.47(b)(2), 71.47(b)(3), and 71.51(a)(2).

5-7 Provide information on the tallies used to calculate external dose rates, as described below.

The applicant did not provide any information on the tally locations within the application. The applicant provides a cartoon drawing of the tally surfaces in Figure 5.1.1, 5.1.2 and 5.1.3 of the application; however, it is not clear where dose rate evaluations are made especially considering that these sketches are 2-D. External dose rates at every point on every surface needs to be considered.

The applicant needs to provide more specific information discussing the surfaces and locations where external dose rates are calculated and identify the surfaces and locations on the surfaces where the maximum dose rates occur. If every location on every surface is not evaluated, the applicant needs to provide a justification for the selected locations, i.e., if the package and source geometry are symmetrical, then all surfaces may not need to be evaluated.

Under HAC there is streaming where there are gaps in the plates of the secondary containers and contents may not be symmetrical. Therefore, the applicant needs to justify that the tally specification has taken this into consideration.

Section 5.1.3 of the application states: “The dose rates listed in the tables in this subsection are maximum values. This is achieved by specifying a reasonably fine grid of dose locations around the cask, and selecting the highest values.” The staff is unable to determine if the grid of dose locations is reasonably fine because the applicant did not provide any information on the tally specifications, including the grid (mesh) size. If the tally grid is too coarse, then maximum dose rates may be reduced when averaged with lower dose rate locations. The staff requests that the applicant provide additional information on the tally grid used to calculate external dose rates.

This information is needed by the staff to determine compliance with 10 CFR 71.47(b)(1), 71.47(b)(2), 71.47(b)(3), and 71.51(a)(2).

5-8 Provide an analysis of external dose rates at 1m away from the external surface of the corner that is struck during the bottom center of gravity over corner (BOT-CGOC) 9m free drop simulation.

Section 5.1.3.2 of the application discusses the assumptions used in the model for calculating external dose rates around the package under HAC. This section states: “Chapter 2 shows that the HI-STAR ATB 1T package remains significantly unaltered throughout the hypothetical accident conditions. Localized damage of the cask outer surface could be experienced during the pin puncture, and drop accidents. However, such localized deformations will have a negligible impact on the dose rate at 1 meter from the surface.”

Although the staff agrees that the deformation experienced after the pin puncture would likely have a negligible impact on the dose rate at 1 meter given the margin to the limits, the staff finds that there is significant inelastic deformation, in addition to some loss of material (element erosion), that occurs at the corner directly impacted during the bottom 9m CGOC free drop simulation in LS-DYNA. Figures 5-8.1, 5-8.2 and 5-8.3 below illustrate the extent of inelastic deformation by tracking the change in length of the imaginary line between two points on the package as a function of time: the impacted corner, and the corner on the opposing corner of the package. The graph implies that the struck corner deforms as much as 7 inches during the simulation relative to its pre-impact location terminating, with more than 4 inches of permanent deformation (note element erosion at the impact site around node 328835). Note that other measures could also indicate additional information.

The staff finds that this effect significantly decreases the distance from the source to the detector and could create a streaming path; thus, it cannot be neglected without providing additional information.

The applicant needs to provide a dose rate analysis demonstrating that the simulated deformation and material loss would not cause an increase in external dose rates beyond regulatory limits, while concurrently considering the streaming from conditions of the BFA-tanks and BTC (see RAI 5-5).

This information is needed by the staff to determine compliance with 10 CFR 71.51(a)(2) and 10 CFR 71.73(c)(1).

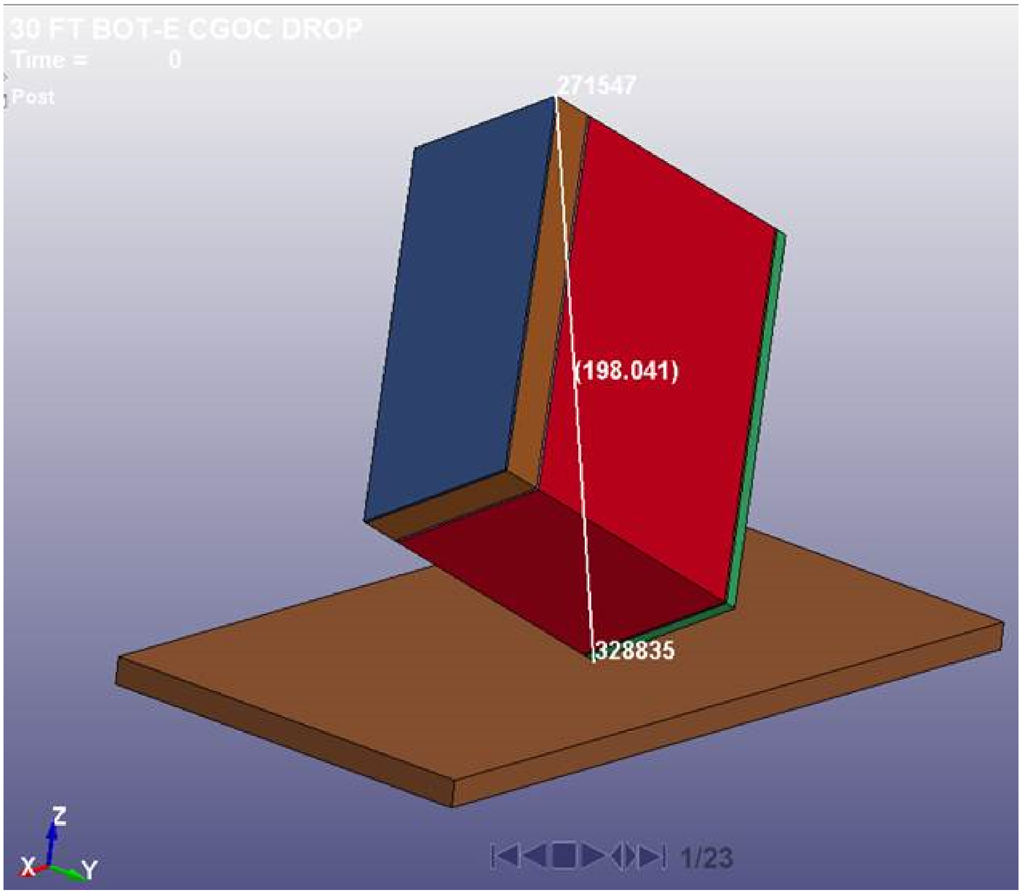


Figure 5-8.1

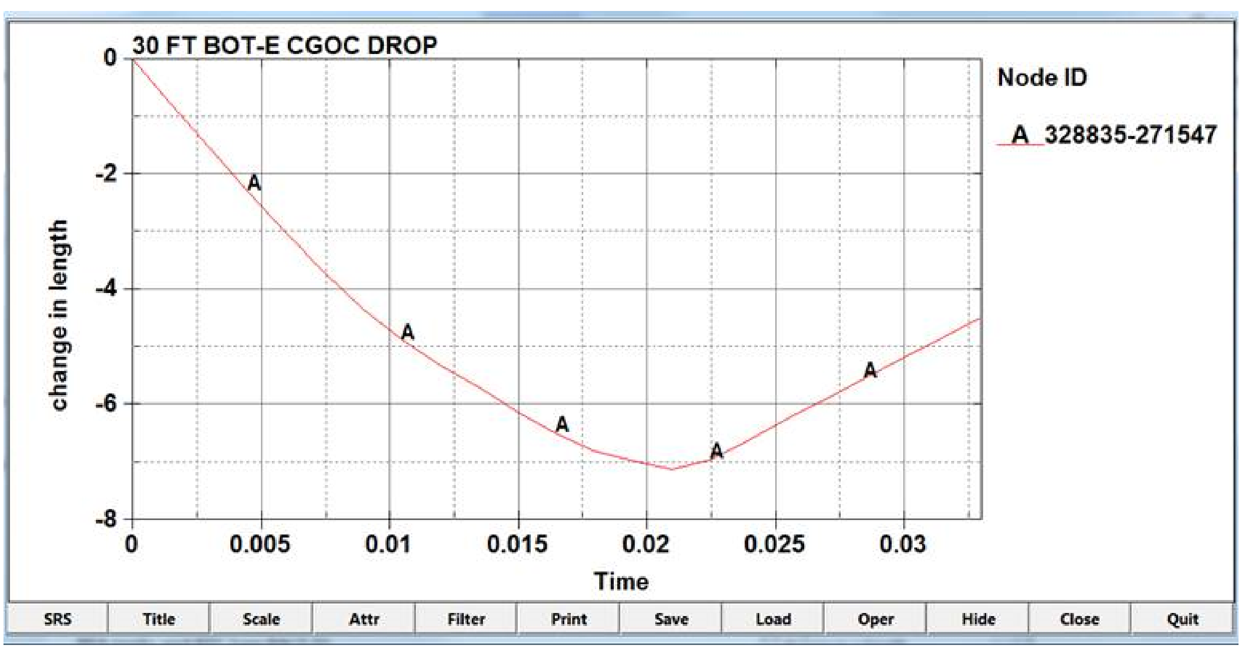


Figure 5-8.2

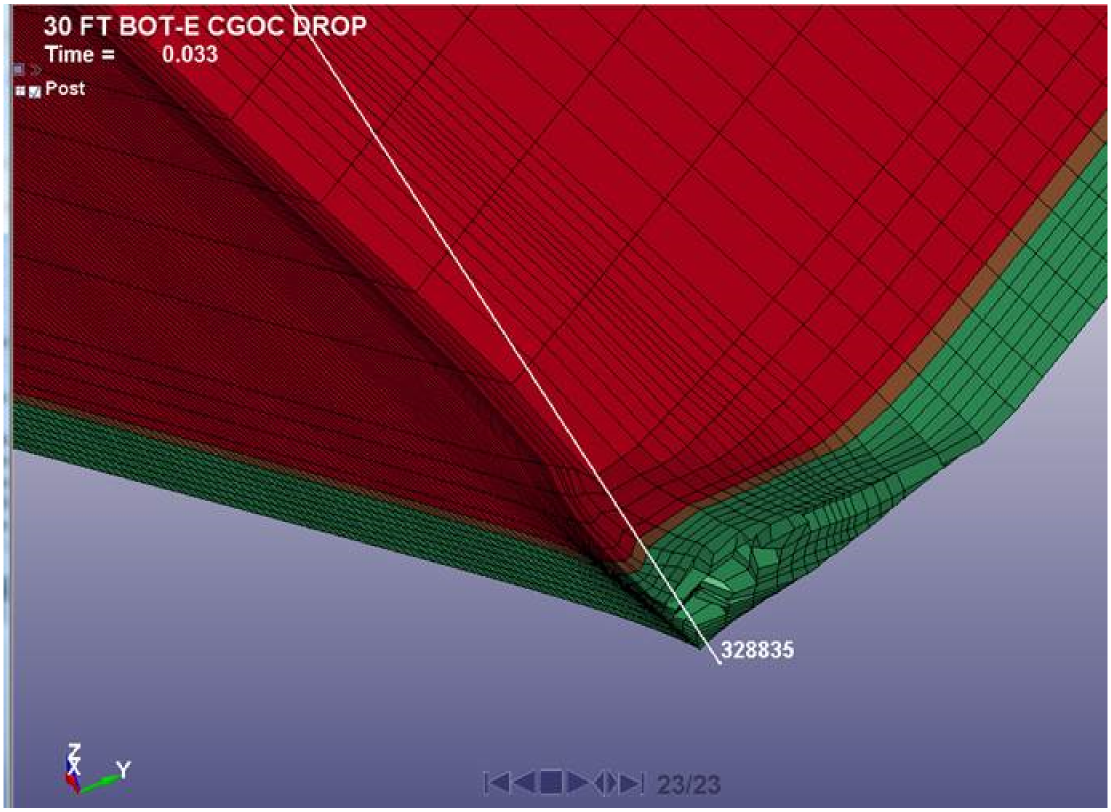


Figure 5-8.3

Chapter 7 Operating Procedures

7-1 Clarify how the BFA-tank cassettes (BTCs) will be lowered into the BFA-Tank when the Docking Protective Cover is still in place over the BFA-Tank.

Section 7.1.1.2 details that a Docking Protective Cover will be placed on the BFA-Tank to prevent water from contaminating the interior of the BFA-Tank during installation of the BTC. It is unclear how the BTC can be docked inside the BFA-Tank with the Docking Protective cover apparently still in place (see Section 7.1.2.1 of the application).

This information is needed by the staff to determine compliance with 10 CFR 71.87(f).

7-2. Clarify in the procedures section when the lifting device that will be used to lift the BFA-Tank will be installed to lift the BFA-Tank for Loading Scenario 2 (LS-2).

Step 7 of Section 7.1.2.2 states: *"The BFA-Tank lifting device is removed from the BFA-Tank."* However, installation of the lifting device itself appears to never have been mentioned in LS-2 loading procedures.

This information is needed by the staff to determine compliance with 10 CFR 71.87(f) and 71.33.

7-3 Clarify what actions will be taken when the ATB 1T cask is found to have an impaired physical condition beyond superficial marks and dents when preparing for loading or unloading.

Section 7.1.1.1 and 7.2.1 of the application state that, if there is any indication of damage observed during loading preparations beyond superficial marks and dents, site management would be notified. However, it is unclear (i) if any loading preparations will be stopped, and (ii) if or when any corrective actions/repairs will take place.

This information is needed by the staff to determine compliance with 10 CFR 71.87(b).

7-4 Clarify in the procedures section the minimum width of the lifting device used to lift the ATB 1T package by its trunnions.

Page 24 of document HI-2177540R0 indicates that the minimum plate thickness of the device used to lift the package by its trunnions is 20 mm (anything smaller could damage the trunnions). However, the minimum thickness of the lifting device is not described in the procedure.

This information is needed by the staff to determine compliance with 10 CFR 71.45.

7-5 Modify Chapter 7, "Package Operations," to include specific details of how a user must interpret "specific activity" in Table 7.1.2 of the application.

Table 7.1.2 of the application contains specific activity limits for each of the five configurations. This table states: "Maximum permissible Co-60 specific activity of any single waste item loaded into respective BFA Tank (GBq/Kg)." The staff finds that this could be interpreted in a non-conservative way depending on how a user considers a "single waste item." For example, if this is interpreted as an item with multiple parts, some of these parts could be more activated than others and may possibly relocate during NCT and HAC, thus creating a scenario where areas of greater activity are being separated from areas of less activity that are providing self-shielding.

The applicant needs to (i) provide additional information within the package operations, instructing a user on what exactly is meant by "single waste item" and (ii) ensure this definition is consistent with or bounded by the assumptions within the shielding evaluation in Chapter 5 of the application.

This information is needed by the staff to determine compliance with 10 CFR 71.47(b)(1), 71.47(b)(2), 71.47(b)(3), and 71.51(a)(2).

7-6 Provide the acceptance criteria that ensures the CLLS system has been fully engaged/locked and will provide containment for internal and external pressures.

Section 7.1.3 indicate that Locking Wedge Locking Pins are inserted to ensure the CLLS remains engaged during shipment. However, an acceptance criteria, such as locking pin insertion length or hydraulic pressure for locking, was not provided. The acceptance criteria would be the equivalent of a bolt torque for a typical lid closure.

This information is required by the staff to determine compliance with 10 CFR 71.43(c).

Chapter 8 Acceptance Tests and Maintenance Program Evaluation

8-1 Clarify the acceptance tests and criteria for determining the shielding is functional post-fabrication, modifying them as needed.

In Section 8.1.6 of the application, the applicant provides information on the acceptance tests performed post-fabrication to ensure that the package shielding is functional and fabricated consistent with the assumptions within the shielding evaluation in Chapter 5 of the application.

The staff does not have enough information to determine that the post-fabrication tests and acceptance criteria are adequate for determining that the package shielding was fabricated consistent with the assumptions in Chapter 5 of the application and the design drawings. Section 8.1.6 states the following: "An inspection using a calibrated radiation detector and a ^{60}Co source will be performed. Acceptance criteria will be defined by comparative measure on mock-up or reference blocks produced using the casting technique used for the as-built cask components and having calibrated defects."

The applicant needs to include additional information on the requirements of the inspection. The applicant needs to provide more specific acceptance criteria and clarify the above language as the staff does not understand what is meant by "reference blocks produced using the casting technique used for the as-built cask components and having calibrated defects." The acceptance criteria should have a clear connection between them and demonstrate that the as-fabricated package meets the minimum design specifications in the design drawings and the assumptions regarding the packaging in the shielding evaluation.

The applicant also needs to specify procedures for determining acceptance of the BFA-Tanks and cassettes as these components are used as shielding and considered important for safety.

This information is needed by the staff to determine compliance with 10 CFR 71.85(a).

8-2 Clarify the acceptance tests and criteria for determining that the shielding is functional pre-shipment, modifying them as needed.

In Section 8.1.6 of the application, the applicant provides information on the acceptance tests to be performed prior to the first shipment (pre-shipment after first loading). This section states: "Measurements shall be taken at locations specified by the user's radiation protection program for comparison against the calculated values in this SAR for the specific loaded contents and BFA-Tank/BTC combination (when applicable) to assess the continued effectiveness of the shielding. If the measured dose rates are higher than the calculated values, then the cask shall not be shipped until the root cause is determined, appropriate corrective actions are completed, and the cask is re-tested with acceptable results."

The staff does not find these procedures capable of determining if the package shielding is effective. As the calculated values in the application are design basis, comparing against any non-equivalent source would not provide any information on whether or not the shielding is effective. For example, a user could load a source with strength significantly less (e.g. 5%) than that of the design basis, and if the measurement shows that external dose rates with this source are less than that of the application, e.g., even if it is 95% of the limit, then the package shielding is still considered effective when it is possible that the package shielding is underperforming.

The applicant needs to modify the acceptance criteria to compare the measurement with a calculation using an equivalent source for both the measurement and the calculation.

This information is needed by the staff to determine compliance with 10 CFR 71.85(a).

8-3 Clarify in the SAR that those approving the leakage test procedures and performing the leakage tests are qualified.

Section 8.1.4 indicates that testing shall be performed per written and approved procedures. However, there were no details in the SAR of the qualifications for those approving the procedures and performing the tests. For example, ANSI N14.5-2014 provides information on the qualification and certification of personnel performing leakage rate tests. Likewise, an individual who has obtained certification as an American Society for Nondestructive Testing nondestructive testing Level III in leak testing has the qualification necessary to develop and approve written instruction for conducting leakage rate testing.

This information is needed to determine compliance with 10 CFR 71.51(a).

8-4 Justify that the elastomeric seals do not have to be replaced on a yearly basis.

Table 8.2.1 indicates that elastomeric seals do not have to be replaced, remaining part of the containment boundary for an indefinite period unless visual inspection shows that replacement is necessary. This is not consistent with NUREG-1609 (page 8-6) which indicates that elastomeric seals are replaced, at least, on a yearly basis. Details of the material performance justification and qualified acceptance criteria of inspection should be provided to understand the rationale for the indeterminate acceptance period.

This information is required by the staff to determine compliance with 10 CFR 71.43(d).

8-5 Remove Note 2 of Table 8.1.1 which states that alternative types of leak rate tests may be used.

An applicant may use various types of leak rate tests to ensure that regulatory release rates are met. However, the leak rate tests are to be specified and described in the SAR so that an evaluation can be performed.

This information is required by the staff to determine compliance with 10 CFR 71.51(a).