NRC RAI 1-1:

Provide tolerances on the licensing drawings.

General note E on sheet 1 of 7 of licensing Drawing No. 9786 describes how tolerances in the drawings are to be used but the title block, in the lower portion of the drawing, does not provide any tolerances. Tolerances are used to determine compliance with package weight limits, and the thermal stresses due to material expansion, as well as component interaction during drop simulations.

This information is required to determine compliance with the requirement of Title 10 of the *Code of Federal Regulations* (10 CFR) 71.33(a)(5).

Holtec's Response to RAI 1-1:

This drawing note is meant to convey that in those instances where control of tolerances is required to support licensing basis analysis, they will be shown with appropriate tolerances or limits. Although other dimensional controls may be required for fabrication fitup or operational clearances, these will be represented on the licensing drawings as nominal dimensions only, with appropriate dimensional control added in the fabrication drawings. Hence, a standard tolerance is deliberately not established in the title block. (The "N/A" listed in the title block is an artifact of Holtec's use of this standard title block for both licensing and fabrication drawings; default tolerances would be typically applied to fabrication drawings, for convenience. To avoid confusion, this table has been removed from both drawings 9786 and 9876.)

To specifically address the concerns listed in the RAI:

- Weight limits are established in the FSAR Table 7.1.1. These limits are based on conservative estimates of the final weight of the components that account for fabrication knowledge such as the typical variation in plate thickness, machining tolerances and weld sizes. Compliance with package weight limits is controlled by appropriate dimensional tolerancing or other controls at the fabrication level, such that the weight of fabricated components complies with the bounding limits applied to the safety analysis. Dimensional tolerances in the licensing drawings to control component weight are therefore generally not required, as is the case with the ATB1T cask.
- Depending on the safety-significance of the thermal expansion, dimensional control may be applied to the licensing drawings to limit materials stresses. However, due to the relatively limited range of operating temperature of the ATB1T cask, no thermal stresses have been identified as a safety-significant concern, and thus no dimensional controls are applied for this purpose.
- Examples where dimensions are controlled to support analysis limits for component interactions during drop analysis are found in Flag Notes 4 and 13 of licensing drawing 9786, which limits the clearance between the BFA-Tank and cask cavity height to 10mm or less, and the clearance at the BFA-Tank side walls to the side shim assemblies to 3mm or less. These clearances are controlled due to the analysis model sensitivity to the relative accelerations between these two components during drop accident analyses.

Two other examples of where dimensional tolerances are applied to the drawing to support safety-significant analysis assumptions can be seen on Sheet 3 of drawing 9786, where a 7 ¾" MIN dimension is established for the overall cask wall thickness (Detail 3D) and a 5 ¼" MIN dimension is established for the lifting trunnion diameter (Detail 3B). In these cases, respectively, the minimum wall thickness dimension supports the safety-related shielding analysis and the minimum trunnion diameter supports the safety-related lifting/handling analysis. Compliance with these dimensional requirements will be established through appropriate tolerancing in the fabrication drawings.

NRC RAI 1-2:

Provide a drawing of the closure lid insulation board to ensure proper fit and function within the package.

Page 3-29 of the application states that an insulation board is needed to protect the seal from reaching high temperatures. Although part number 26 (sheet 2 of 7 of drawing 9786, Rev. 5) notes that the insulation board is Important-to-Safety (ITS), both a drawing and specifications were not included in the application.

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

Holtec's Response to RAI 1-2:

Additional dimensional details of the insulation board are provided in Revision 6 of Drawing 9786, on newly added Sheet 8. Flag note 6 of drawing 9786 specifies the material to be used, with other material requirements described in Subsection 2.2.2.1 of Chapter 2. A specification sheet for this material is added for information in Appendix 1.A of Chapter 1. Per flag note 6, material with same thermal resistance may be substituted. Thermal resistance, defined as the ratio of material thickness to thermal conductivity, is the only critical characteristic for this material. Like other cask materials, insulation board must be capable of operation at all normal and accident temperature conditions.

NRC RAI 2-1:

Incorporate the spaces, in accordance with the licensing drawings, between the BFA- Tank, the containment boundary, and the BTC, in the drop simulations and describe the condition of the ATB 1T package for all drop simulations which incorporate them.

The applicant assumes in Section 3.7 (page 14) of document HI-STORM 2177539 that, during the 30ft top end drop simulation, no space exists between the BFA-Tank and the closure lid prior to impact. However, drop testing of the ¼ scale model of the ATB 1T at Sandia National Laboratories, in September 2016, showed that a gap naturally forms between the internals and the containment boundary as witnessed for the 30 ft CGOC drop and as mentioned in the ¼ scale drop report (HI-2167515R2). This gap forms due to the relaxation of stressed components upon package release.

The licensing drawings indicate that the BFA-Tank has at least a 3/8" of clearance between it and the containment boundary for this gap to form. Likewise, the same models, used in drop simulations, assume no gap exists between the BTC and the BFA- Tank. When calculated from the licensing drawings, a clearance between 26 mm and 64 mm exists between these two parts, allowing a gap to form between them upon package release in all drop simulations.

Higher stresses are expected in the containment boundary as a result of internals striking each other and the containment boundary, due to these gaps forming during real drop tests. Update all corresponding calculations and drop simulations and the application, as necessary.

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

Holtec's Response to RAI 2-1:

The assumption of zero gap between the cask cavity and its internal contents at the time of impact is consistent with other 10CFR71 applications submitted by Holtec and approved by the NRC viz. HI-STAR 190, HI-STAR 180 and HI-STAR 180D.However, the internal gaps are considered in the revised calculation and SAR based on the feedback from NRC staff.

The initial gaps expected between the cask cavity and the BFA-Tank due to elastic springback between interfacing components are incorporated in the revised drop analyses. The applicable internal gaps between the cask cavity and the BFA-Tank just before the primary impact are considered as follows:

1. For the 30 ft. HAC accidents the nominal gaps based on the cask cavity and the BFA tank dimensions are used in the drop analysis.

2. For 1-m puncture and 0.3-m NCT drops, the initial elastic springback between the cask cavity and the BFA-Tank prior to the impact with the target are estimated based on a single degree of freedom mass and spring idealization of the problem. The computed gaps between the interfacing components in the direction of impact is postulated as the initial condition between the cask cavity and the BFA-Tank in the drop simulations.

The revised analyses, therefore, appropriately capture the secondary impacts between the Cask and the BFA-Tank.

On the other hand, gaps are not considered between the BFA-Tank cavity and the BFA Tank Cassette (BTC) due to the apparent conservatisms noted in the drop simulation model:

1. BTC components viz. the top/bottom plates, the side walls and the corner bars are modeled as rigid bodies resulting in overestimating of the cask dynamic response.
2. The BTC content mass is uniformly smeared into the BTC component which is in the path of direct impact. For example, the content mass is smeared into the BTC top plate during the top end drop. This results in overestimating the cask dynamic response.
3. The energy/momentum loss due to deformation of contents or non-coherent impacts is ignored in the current analysis.
4. Assuming zero gap between the BFA-Tank cavity and the BTC maximizes the impact momentum transfer between the BFA-Tank (plus contents) and the HI-STAR ATB 1T cask cavity, which in turn maximizes the structural demand on the cask containment boundary including the closure lid seal. Conversely, a non-zero gap between the BFA-Tank cavity and the BTC would further stagger the impacts (i.e., primary, secondary, tertiary) and lessen the peak instantaneous demand on the cask containment boundary.

In light of the above conservatisms, no gaps are considered between BFA-Tank and BTC in the drop simulation model.

NRC RAI 2-2:

Verify that a space does not exists between the directly loaded contents and the lid of the ATB 1T.

The licensing drawings indicate that a 3/8" space exists between the BFA-Tank and the closure lid of the ATB 1T (Note 4 on Licensing Drawing 9786). However, it is unclear what space exists for directly loaded material, since no BFA-Tank is being used for this loading case.

Update the licensing drawings with this description as necessary.

This information is required to determine compliance with the requirement of 10 CFR 71.33(a)(5).

Holtec's Response to RAI 2-2:

Holtec is no longer seeking approval to load waste directly into the HI-STAR ATB 1T cask without a BFA Tank. This loading option, which was referred to as Waste Package Type E in the previous SAR submittal, has been completely eliminated in Proposed Revision 3 of the HI-STAR ATB 1T SAR. Going forward all waste contents must be loaded in one of four available BFA Tanks (associated with Waste

Package Types A through D in SAR Table 7.1.2) prior to being placed inside the HI-STAR ATB 1T cask.

NRC RAI 2-3:

Justify how the mass of the BTC contents is modeled in drop simulations.

Calculation 5 of document HI-2177540R2 states, in part, that the BFA-Tank and BTC must meet the following requirements:

1. The BFA-Tank walls including the top and bottom plates must not be subject to gross failure under the postulated normal and hypothetical accidental drop conditions. It implies that the walls including the top and bottom plates must not be subjected to buckling (gross yielding) under the inertia/loads resulting from drop accidents.

2. The connections between the BFA-Tank walls and the top and base plates must not be subject to gross failure under the normal drop conditions (NCT).

3. The BTC corner reinforcing must not buckle or suffer gross *yielding under the postulated normal drop events.*

4. The BTC the top and bottom plates must not separate from the corner structural bars under the postulated normal drop events.

The applicant has lumped all of the mass that represents the contents of the BTC (BFA- Tank cassette) to its lid (model part 29) for all drop simulations. While this approach may be appropriate, and/or conservative, for some drop simulations, it does not appear to be so for others.

For instance, the contents of the BTC during the side drop or CGOC drop simulation would be distributed close to the target upon package impact. but the lid of the BTC does not necessarily have to be. The greatest challenge to the containment boundary, BFA-Tank, and BTC, is expected when the contents are distributed as per actually loaded conditions, which tend to be close to the impact location.

In addition, the decelerations observed for the BTC do not match the calculations. The applicant's calculations assume that the BTF-Tank observes decelerations of 400 g while the BTC observes decelerations of 300 g. However, these values are exceeded by the top and bottom plate of the BTC (357 g) during the 30ft top end drop. The bottom plate (Model part 29) of the BTC also experiences decelerations exceeding 800 g during the 9 m side drop simulation. In addition, the corner columns of the BTC (model part 25) are assumed to observe decelerations of up to 100 g, but do not appear to be stressed nor are other model parts (27 and 28) of the BTC for any drop simulation that was submitted.

Describe the performance of the package when the contents of the BTC are free to occupy the cavity of the BTC in a more realistic way for all postulated drop simulations and update calculations and the entire application, as necessary.

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

Holtec's Response to RAI 2-3:

Key information related to the modeling and acceptance criteria of the BTC is discussed below.

• In the revised drop simulations, the BTC content mass is smeared onto the BTC component which is directly in the path of impact. For example, for the cask top end drop simulations, the mass of the BTC contents is smeared onto the BTC top plate. Likewise, for the bottom end the mass is lumped with the

BTC bottom plate. However, since the BTC components are simulated as rigid bodies, the individual component mass has no significant effect on the cask dynamic results. Furthermore, the representation of BTC content mass as being attached to the BTC renders conservative to the drop simulations for the following reasons:

(i) This modeling approach ensures that BTC contents move coherently with the BTC thereby maximizing the impact severity from the cask internals. In other words, the BTC contents are expected to move in a non-coherent manner resulting in phased impacts. Out of phase motion of the BTC contents implies lesser impact force at any time instant.
(ii) Internal energy dissipation due to BTC content is ignored due to rigid mass representation.
(iii) Frictional losses due to relative motion between the BTC contents is also ignored.

• It shall be noted that the acceptance criteria discussed in the comment only apply to the NCT drops. There are no performance requirements or structural acceptance criteria for the BTC under hypothetical accident conditions (HAC) since the shielding evaluations in SAR Chapter 5 take no credit for the BTC components.

• The BTC to BFA Tank impact force from the 1-ft drop simulations are reported in the revised calculation package HI-2177539 Revision 4. Peak decelerations are calculated based on contact force time history and the mass of BTC plus its contents. Subsequently, the bounding deceleration is used for the BTC structural evaluation in HI-2177540 Revision 3.

• The BFA Tank peak deceleration time histories are directly reported in calculation package HI-2177539 Revision 4 for the governing 30-ft HAC and 1-ft NCT drops, which are used to inform the BFA Tank structural analysis in calculation package HI-2177540 Revision 3.

NRC RAI 2-4:

Justify the material flow curves used to perform sensitivity studies of the impact limiter components.

The applicant uses material flow curves for aluminum and stainless steel that are amplified by 10%, to demonstrate that materials with higher than minimum tabulated ASME values will not negatively impact the performance of the package. However, the value of 10% appears to be unsubstantiated.

Tabulated ASME material properties are expected to be exceeded 95% of the time based on a minimum of 5 samples. With this consideration in mind, the applicant shall (1) compare the 10% amplification to the one expected that insures that minimum flow curve properties are exceeded only 5% of the time, (2) update the sensitivity analysis, and the application, and (3) update drop simulations as necessary.

Additionally, the applicant shall confirm that the amplified simulations (Simulation C1), tabulated in Tables C.1 and C.2 of document HI-2177539R3, do result in *reduced* component stresses values rather than *increased* stress values, when compared to base simulations (Simulation 1).

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

Holtec's Response to RAI 2-4:

- The 10% exceedance on material flow curves establishes the acceptable range for material strength properties (as chosen by Holtec). The variance/exceedance limit on the material yield or ultimate strength will be captured in the material purchase specification(s) and imposed on the supplier.

- For the crushable attachments, any material strength exceedance beyond the established 10% limit will need to be further evaluated using the same licensing basis drop simulation model and methodology, as discussed in Section 2.7.1 of the SAR, to demonstrate safety compliance.

- Based on the revised drop simulations, the safety results from the sensitivity simulation show close correspondence to the base simulation results. This is observed from Table C.1 and C.2 of the calculation package HI-2177539, Revision 4.

- Where the results from sensitivity simulations exceed the base simulation results, the increased results are discussed in the calculation package and the safety case for the package is still demonstrated.

NRC RAI 2-5:

Provide design calculations for the BFA-Tank lid bolts and additional dimensions of the BFA-Tank lid.

The applicant states that the BFA-Tank lid is recessed (Detai12C, Sheet 2 of licensing drawing 9876) so that, in the event of a side drop, the recess in the lid protects the lid bolts from shearing (Section 6.2 of document HI-2177540R2). However, the recess dimensions have not been provided.

Without such dimensions, it is unclear how the BFA-Tank bolts would not be subject to shear, especially during an end drop where the BFA-Tank walls/lid bolts would experience shear, regardless of the lid recess specified.

In addition, the BFA-Tank lid bolts themselves observe direct loading during free drops, particularly during a top end drop of any kind, as the BTC would impact the BFA-Tank lid during a free fall, because of the gap forming between the two during an actual free fall, as a result of the relaxation of stressed components upon package release. It is noted that the BFA-Tank lid bolts prevent gross failure/separation of the BFA-Tank lid to the BFA-Tank side walls, a criteria that is specified in calculation 5 of document HI-2177540R2.

This information is required to determine compliance with 10 CFR 71.71(c)(7).

Holtec's Response to RAI 2-5:

Per the acceptance criteria in Subsection 2.1.2.2 of the SAR, the BFA-Tank lid bolts are required to remain intact only under Normal Conditions of Transport (NCT). Failure of the bolts under Hypothetical Accident Conditions (HAC) is permissible since the shielding evaluation in SAR Chapter 5 assumes a 4-cm gap between the BFA-Tank lid and the adjoining walls under HAC conditions. Accordingly, the structural capacity of the BFA-Tank lid bolts is only evaluated for NCT loading.

The design calculations for the BFA-Tank lid bolts in Calculation 5 of Holtec report HI-2177540 have been updated to reflect the latest NCT drop simulations results from SAR Chapter 2 and Holtec report HI-2177539. In doing so, no credit has been taken for the recess in the BFA-Tank lid, and therefore the full inertia load of the BFA-Tank lid under a 1-ft side drop is assumed to be resisted entirely by the BFA-Tank lid bolts acting in shear. Since the recess in the BFA-Tank lid is no longer credited in the strength evaluation, and it is not relied upon to provide any load bearing function, the recess in the lid is designated as a not important-to-safety (NITS) feature, which is depicted on licensing drawing 9876, but does not require dimensioning.

In addition to the shear loading discussed above, the tensile load on the BFA-Tank lid bolts due to 1-ft top end drop is also evaluated in Calculation 5 of Holtec report HI-2177540.

NRC RAI 2-6:

Justify the ratio of hourglass energy to internal energy observed for certain parts of the ATB-1T package during drop simulations in LS-DYNA.

As stated by the applicant, the ratio of hourglass energy to internal energy should be kept to a ratio of 10% or less, as hourglass energy indicates that a nonphysical part of internal energy is present in the model, which, in turn, implies that deformations and the overall physical behavior of the part may not be realistic simulated.

Several drop simulations, such as the 30 ft top end drop, exhibit ratios for certain parts which grossly exceed 10%; as an example, the top lid of the BTC (model part 29) observes a ratio of 130%, part 23 (intermediate dose blocker plate) in the model observes ratios of greater than 30%, and several others parts, not mentioned here, exceed 10% by smaller amounts.

According to calculation 5 of document HI-2177540R2, the BTC side walls and the top/bottom plates of the BTC have to avoid gross yielding and rupture, which is difficult to ascertain given the large amount of hourglass energy observed. The applicant shall verify and/or justify these large values or update the application and simulated drop sequences, as necessary.

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

Holtec's Response to RAI 2-6:

It is correctly noted that if the hourglass (zero energy mode) contribution is significant (more than 10% of the peak internal energy), it may distort the dynamic response of the cask and its components.

In the revised analysis, it is ensured that:

1. The total hourglass energy is less than 10% of the peak internal energy of the cask.
2. The identical measure (ratio of total hourglass energy to the peak internal energy) for individual parts is also minimized to the extent practical without compromising the overall runtime.

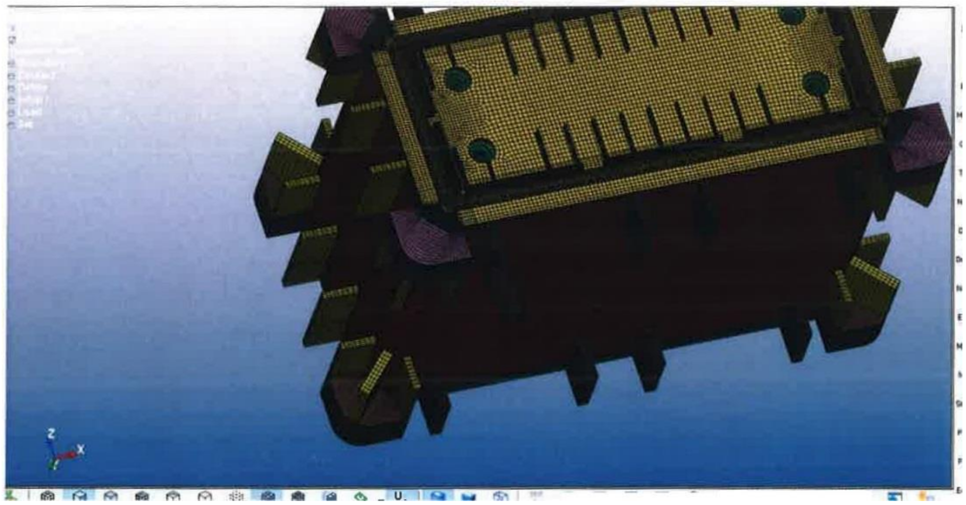
The noted BTC components are also ensured to meet the above criterion.

It shall be noted, however, that the instantaneous energy ratios (viz. ratio of hourglass to internal energy at a specific instant) need not comply with this criterion. For example, in some instances, both the hourglass energy and internal energy magnitude during the start of the simulation is very small (< 10 lbf-in.), as compared to the total energy dissipation (~3.4 e5 lbf-in.) for a particular component. In such cases, the exceedance of instantaneous energy ratio measure has no significant adverse effect on the cask dynamic response or the stress/strain results.

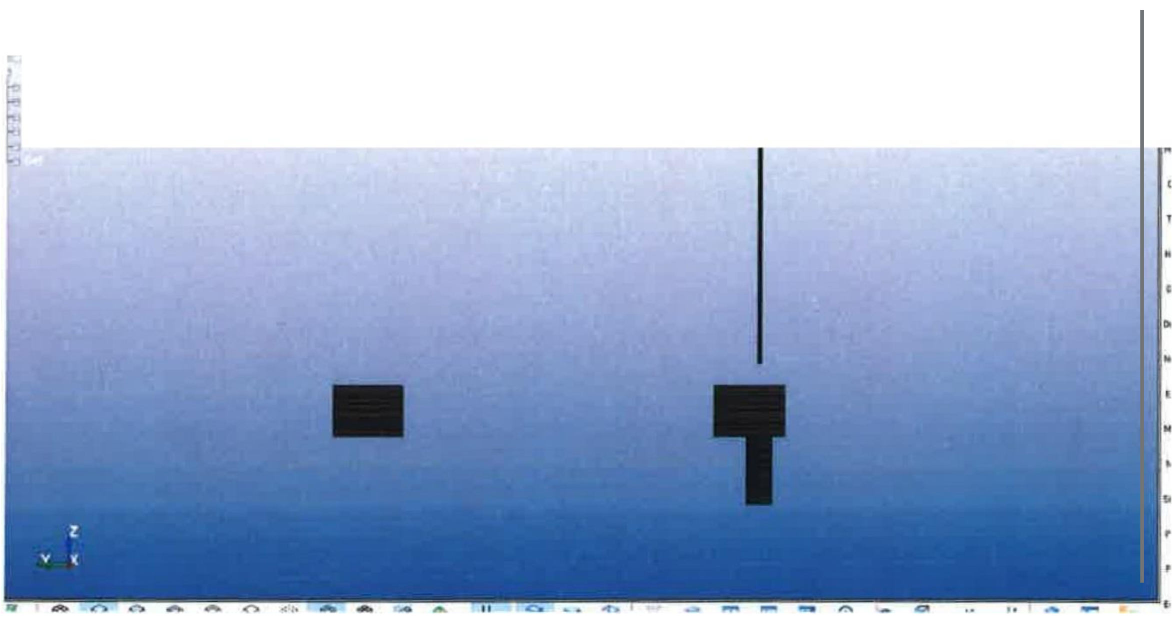
NRC RAI 2-7:

Describe the condition of the sealing surface of the package when subject to the 9 m side drop, followed by a 1 m puncture drop at the side impact absorber near the sealing surface. Clarify and justify how containment requirements will be met given inelastic deformations are observed for the 9 m side drop.

The package's sealing surface (cladding) experiences inelastic deformations after the 9 m side drop next to the side aluminum impact absorbers (BOM 42 of the licensing drawings). It appears that additional damage could be experienced in this region as a result of the 1 m puncture drop (cumulative damage) in the area as shown:



Puncture Bar Centered over Sealing Surface at Side Impact Absorber
(Side Drop Orientation Shown)



Puncture Bar Centered over Sealing Surface (Side Drop Orientation Shown)
Note: Only Side Impact Absorbers and Sealing surface Shown for Clarity

Additional damage in this region could further hinder and jeopardize the package's ability to maintain containment regulatory requirements.

A justification that containment requirements, such as leak rates, will be met given inelastic deformations at the closure region after the 9 m side drop has not been provided (see also containment RAI 4-1). The applicant shall update the application and all associated calculations, as necessary.

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

Holtec's Response to RAI 2-7:

To address NRC staff's concerns, an additional puncture simulation is performed as discussed in Appendix C of HI-2177539 Revision 4.

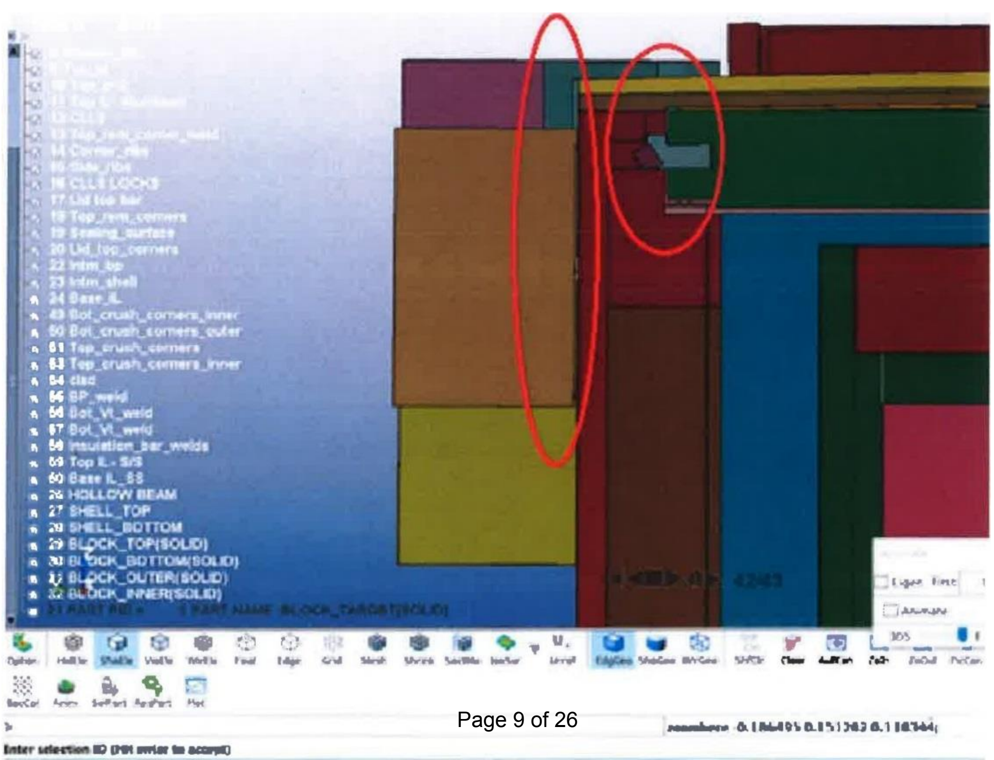
This sensitivity simulation considers a 1-m puncture drop wherein the cask is dropped sideways onto the puncture bar aligned with the seals. Furthermore, this simulation accumulates the damage and deformations (strains) from the 30-ft side drop as the initial condition before subjecting the cask to 1-m side puncture. The analysis and the results from this simulation are documented in Appendix C. The result summary from this analysis is the following:

1. Since the cask center of gravity is offset significantly from the sealing location or point of impact, the cask is subject to rigid body rotation before imparting any significant damage to the HI-STAR ATB 1T package.
2. The seal initial strain result from 30 ft. drop and the corresponding result subsequent to the final 1-m puncture drop remain unchanged. This indicates that the 1-m puncture does not contribute to additional deformation in the seals.
3. All other key containment results subsequent to the 1-m puncture drop remain essentially the same as its initial condition, i.e., 30 ft side drop simulation. There is superficial damage to the outer shell which is not critical for the safety determination of the package.

NRC RAI 2-8:

Clarify the location of the aluminum impact absorber plates on the licensing drawings and their attachment in drop simulations.

Licensing drawing 9786 (Sheet 7 of 7) depicts the relative arrangement between aluminum impact absorbers (BOM part 42). However, their location relative to the cask itself has not been provided. These plates are partially missing from the 1 ft bottom end drop, 1 ft top end drop, and 30 ft BOT CGOC + 1 m puncture drop simulations. In the case of the 1m drops, they also do not appear to be connected, as shown below. In addition, it appears that part 16 of the model, CLLS locks, rotates unnaturally through its neighboring parts.



Impact absorbers are intended to reduce the demands on the containment boundary. It is unclear how "loose" or "missing" impact absorbers will affect the package's performance. The applicant shall update existing drop simulations and the application as necessary, including the licensing drawings.

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

Holtec's Response to RAI 2-8:

The revised dwg. 9786 shows the location/positioning of all the crushable attachments (impact absorbing components) relative to the cask.

It is correctly noted that some of the crushable attachments, which are not critical for a particular drop orientation, do not correspond to the actual sizing and positioning shown on the dwg. 9786. For example, the side attachment bars (i.e., part 42) are only shown for representation in the simulation model used for end drops. Likewise, the top and bottom bars are not critical when performing the side drops. This simplified representation is justified and is acknowledged in the calculation package HI-2177539 Revision 4. This modeling simplification has no adverse influence on the package safety determination.

It is also ensured in the revised calculation HI-2177539 Revision 4, that part 16 of the model viz. CLLS lock has proper contact with the adjacent cask components.

NRC RAI 2-9:

Clarify the thickness of the closure lid and dose blocker plates.

Section 4A-4A on sheet 4 of 7 on licensing drawing 9786 depicts that the combined minimum thickness of BOM items 19 and 20 is 8.125 inches. However, the models, used to perform drop simulations in LS-DYNA, indicate that the combined thickness of these parts is only 7.75 inches.

It is unclear how the package will behave, with effectively less mass and stiffness, during drop simulations. Such changes could also increase the stresses on the package as a whole, as well as on the containment boundary.

The applicant shall clarify the thickness of the closure lid and dose blocker plates and justify the impact this thickness has on the stress margins, the licensing drawings, and update the application as necessary.

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

Holtec's Response to RAI 2-9:

The revised model accurately considers the thickness of all the parts including the parts specifically identified in this RAI.

It shall be noted that the inner lid surface extends 1/8" into the cask cavity. Also, the earlier drop simulation model ignored the ¼" gap where the insulation board is sandwiched between the closure lid and the top DBS (dose blocker structure) part. The current model includes this ¼" cavity space explicitly.

NRC RAI 2-10:

Clarify the dimensions describing the lifting lugs.

Calculation 4 of document HI-2177540 depicts lifting lug dimensions t, and t2 (BOM Part 30 on the licensing drawings) as being 0.63 inches. However, Section 4A-4A on Sheet 4 of licensing drawing 9786 depicts these dimensions as being 0.5 inches.

Describe what impact this has on the lifting calculations and update the licensing drawings and the application, as necessary.

This information is required to determine compliance with 10 CFR Part 71.45(a).

Holtec's Response to RAI 2-10:

The lid lifting calculation is revised to correspond to the dimension noted on the licensing dwg. 9786. The corresponding safety results are updated in the SAR. The minimum safety factor based on the revised calculation is noted as 1.44 for the lug welds, as documented in Calculation 4 of HI-2177540 Revision 3.

NRC RAI 2-11:

Verify the model used to represent the BTC, the loads observed in the BTC, and the BTC's relative position within the BFA-Tank during drop simulations.

Calculation 5 of document HI-2177540R2 states (in part) the criteria used to examine the BTC:

3. The BTC corner reinforcing must not buckle or suffer gross yielding under the postulated normal drop events.

4. The BTC top and bottom plates must not separate from the corner structural bars under the postulated normal drop events.

However, drop simulations for NCT and HAC, such as the bottom end 1 m drop and bottom end 9 m drop, show that the BTC side walls (model part 32) appear to be not connected to the BTC top (model part 30) nor the BTC bottom plate (model part 29). This implies that the applicant's specified criteria of plate separation have been violated.

Specifically, the side walls of the BTC move independently from the top and bottom plate which seem to move in unison. This may be the reason why the corner reinforcing (model part 25) and remaining portion of the BTC model parts 27 and 28 do not observe any loading for any drop simulation submitted.

The applicant shall update all drop simulations, calculations, and the application results as necessary.

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

Holtec's Response to RAI 2-11:

As shown on licensing drawing 9876, the BTC side walls are only connected to the corner bars, and they do not make contact with the BTC top and bottom plates. In other words, there is a clearance gap between the top and bottom edges of the BTC side walls and the BTC top and bottom plates. In addition, the licensing drawing indicates that the BTC side walls are optional components, which are designated as Not Important to Safety (NITS). Accordingly, the structural and shielding evaluations for the HI-STAR ATB 1T package do not take any credit for the BTC side walls.

The LS-DYNA model of the BTC, which is utilized for drop analyses, is consistent with the licensing drawing insomuch as the side walls are physically connected to the corner bars with distinct gaps between the side walls and the BTC top and bottom plates (see SAR Figure 2.6.7). The reason for including the BTC side walls is simply to maximize the mass of the package, which in turn maximizes the potential energy associated with the drop event. The entire BTC assembly is modeled as a rigid body in LS-DYNA for the drop simulations.

For HAC, there are no structural acceptance criteria for the BTC, as indicated in paragraph 2.1.2.2 of the SAR, so the response of the BTC due to a 9-meter drop is not a concern. For NCT, the BTC top and bottom plates must remain connected to the corner bars, and the corner bars must not buckle/collapse as a result of a 0.3-meter drop. To satisfy this criteria, the maximum impact deceleration associated with the BTC is obtained from the 0.3-meter drop simulations, and the maximum impact deceleration is then used to evaluate the structural integrity of the corner bars and its connections to the BTC top and bottom plates outside of the LS-DYNA numerical simulations. These calculations are documented in Calculation 5 of Holtec report HI-2177540, which shows that the BTC maintains its structural integrity following a 0.3-meter drop event.

NRC RAI 2-12:

Justify or quantify that a sufficient amount of water will not be available to produce flammable hydrogen by radiolysis following the vacuum drying process.

To prevent flammable conditions, hydrogen concentrations are limited to less than 5% by volume. Section 1.2.2 of the application states, in part, that the package contents include secondary waste (i.e. debris/chips) generated by the mechanical cutting process, chip drums with surface contamination or induced activity and metallic waste filters (stainless steel or ceramic mesh screens) in the chip drums. Because the chips and mesh screens may hold residual water, the staff requires additional information that demonstrates that the potential amount of residual water after drying is not capable of generating flammable levels of hydrogen due to radiolysis.

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

Holtec's Response to RAI 2-12:

The bottom and lower sides of chip drums are constructed from a perforated metal. This design of chip drums is to prevent pooling of residual water after the drums are lifted out of water. Water is drained by gravity when the cassette loaded with the drums is lifted out of water. Since bottom of the drums is perforated there is no residual pooled water. The remaining moisture on the wet surfaces of the chips is dried during the vacuum drying process of the BFA-tank through the perforated walls of chip drums. To prevent flammable conditions and maintain hydrogen concentrations less than 5% by volume, the vacuum drying process is continued until the required vacuum is reached and maintained as per the drying procedure. Drying criteria are in Table 7.1.1.

To clarify, the sixth paragraph in Section 1.2.2 of the HI-STAR ATB 1T SAR was updated to state that: "The chip drums design allows water to drain by gravity, prevents pooling of residual water and facilitates moisture removal during vacuum drying process."

NRC RAI 2-13:

Further justify why the carbon steel used to fabricate the BFA-Tank and BTC does not require fracture toughness testing by providing additional information demonstrating that the BFA-Tank and BTC will not undergo gross failure or will fail only in the intended manner (e.g., cracks of a limited width).

The BFA-Tank and BTC are designated as ITS components on the licensing drawings. Licensing drawing 9876, flag note 1, specifies that they are made of a steel that has minimum mechanical properties of ASTM A36 steel. Section 2.2.5 of the application provides reasons why this structural steel material does not require fracture toughness testing. However, based on the applicant's acceptance criteria, the BFA-Tank and BTC cannot fracture under certain postulated NCT and HAC drops scenarios. Fracture is a failure mechanism which is random in nature and difficult to predict a priori.

Specifically, Calculation 5 of HI-2177540R2 (proprietary) evaluates the BFA-Tank/BTC under NCT and HAC drops and states in part:

1. The BFA-Tank walls including the top and bottom plates must not be subject to gross failure under the postulated *normal and hypothetical accidental drop conditions.* It implies that the walls including the top and bottom plates must not be subjected to buckling (gross yielding) under the inertial loads resulting from drop accidents.

2. The connections between the BFA-Tank walls and the top ahd base plates must not be subject to gross failure under the normal drop conditions *(NCT).*

3. The BTC corner reinforcing must not buckle or suffer gross yielding under the postulated *normal drop events.*

4. The BTC the top and bottom plates must not separate from the corner structural bars under the postulated *normal drop events.*

Elsewhere in the application, the applicant states that during HAC conditions, crack formation in the top or bottom plate of the BFA-Tank/BTC is acceptable; however, gross failure is not.

It is unclear for the staff how the material of the BTC and BFA-Tank will perform in the intended manner when brittle fracture requirements for the material have not been established.

This information is required to determine compliance with 10 CFR 71.47, 10 CFR 71.51 (a}(2), 71.71(c}(2), 71.71(c)(7), and 71.73(c)(1)

Holtec's Response to RAI 2-13:

As discussed in Section 2.2.5 of the SAR, the BFA-Tank and BTC are not relied upon as containment barriers or pressure retaining vessels. Therefore, there is no concern that a thru-wall crack in either component would lead to a radioactive release or a loss of cavity pressure. The side walls and the top and bottom plates of the BFA-Tank, as well as the top and bottom plates of the BTC, are only credited in the shielding evaluation to mitigate dose rates external to the HI-STAR ATB 1T package. This means that a brittle fracture of the BFA-Tank or BTC is only a concern if it adversely affects the licensing basis shielding evaluation. The remainder of this response discusses the possibility of a brittle fracture of the BTC and the BFA-Tank under NCT and HAC, and more importantly its potential effect on calculated dose rates.

For the BTC, brittle fracture is not a concern under HAC. This is because the shielding evaluation of the BTC in SAR Chapter 5 recognizes that the corner tie rods, which maintain the positioning of the BTC top and bottom plates, may fail under a HAC drop allowing the plates to relocate inside the package. Accordingly, the dose rate evaluation for the BTC under HAC conservatively neglects the entire BTC bottom plate, as well as the optional BTC side walls. Thus, even if the BTC top or bottom plate were to suffer a brittle fracture as a result of a HAC drop, the consequences are already bounded by the hypothetical accident dose rate calculations in SAR Chapter 5.

Under NCT, the likelihood of a brittle fracture of the BTC top or bottom plate is extremely low due to the following:

i) With the exception of the 1-foot drop, the load events associated with NCT produce very low stress levels in the BTC. (Note: Structural supports are exempted from impact testing per NF-2311 if the stress is less than 6,000 psi in tension or compressive.)

ii) The BFA-Tank cavity (where the BTC resides) can reach temperatures as high as 230°F (see SAR Table 3.1.3), whereas the ductile-brittle transition temperature for carbon steel is typically between 20°F to 40°F.

Apart from the above, the maximum surface dose rate and the 2-meter calculated dose rate for the HI-STAR ATB 1T package are less than 60% of the allowable limit per 10 CFR 71.47 (see SAR Tables 5.1.1 and 5.1.2). Therefore, even if a brittle fracture of the BTC top or bottom plate were to occur under NCT, there is significant margin available to offset the local dose increase due to a thru-wall crack in the BTC top or bottom plate.

For the BFA-Tank, the situation is similar to the BTC. Under HAC, the shielding evaluation in SAR Chapter 5 assumes that there are 4 cm gaps along all of the corner edges of the BFA-Tank (see SAR Figure 5.3.3). These are the regions where a brittle fracture is most likely to occur due to the gross structural discontinuity and higher bending stresses that develop along the clamped edges of the BFA-Tank side walls, bottom and top cover. The 4 cm gaps are also quite conservative considering the limited clearances between HI-STAR ATB 1T containment space and the BFA-Tank. This nested arrangement severely limits the ability of the BFA-Tank walls to separate, displace or relocate inside the cask containment cavity. Lastly, a sensitivity analysis is also performed in SAR Chapter 5 in which the most activated Type A waste is assumed to bypass the BTC top plate and occupy the gap between the BFA-Tank walls (see SAR Figure 5.3.9), leaving only the side wall of the HI-STAR ATB 1T cask to provide gamma shielding. Even under this worst-case scenario, and for all scenarios analyzed in SAR Chapter 5, the hypothetical accident dose rate meets the applicable limit per 10 CFR 71.51. Thus, the HAC shielding evaluation for the BFA-Tank in SAR Chapter 5 credibly bounds the possibility of a brittle fracture of the BFA-Tank side walls, bottom or top cover. Under NCT, a brittle fracture of the BFA-Tank is very unlikely for the same reasons given above for the BTC.

In summary, the shielding evaluations for HAC in SAR Chapter 5 account for the possibility of a brittle fracture of the BTC and the BFA-Tank. Under NCT, the possibility of a brittle fracture is significantly lower due to stress and temperature considerations. In addition, the calculated dose rates for NCT are below the regulatory limit by almost a factor of 2. All of the above supports the conclusion that the carbon steel plates that are used to fabricate the BFA-Tank and BTC do not require fracture toughness testing.

NRC RAI 3-1:

Clarify uncertainties with the hypothetical accident condition thermal calculations regarding the exterior surface temperature, seal temperature, and cask cavity temperature.

(1) Statements on page 3-30 of the application indicate that a) the decay heat of the waste has negligible impact on the temperature increase of the cask under the fire accident and b) that “the increase in the average temperature of the cask cavity is expected to be smaller than the increase in the average temperature of the cask containment boundary components since the heat from the fire is transferred from outside to inside.”

Considering the above statements, there was no explanation for the temperatures provided in Figure 3.4.1(a) and Table 3.1.2 of the application. For example, Table 3.1.2 indicated that the cask closure lid inner seal, at the end of the fire and at the post-fire period (433°F and 532°F, respectively), is at a higher temperature than the closure lid (252°F and 358°F, respectively), even though the closure lid is adjacent to the fire boundary condition.

In addition, it is noted that these results appear to be different from those of the previous submittal.

(2) the applicant shall provide a description and definition and the locations (relative to the fire boundary condition) of the cask lid, closure lid, containment wall, and base plates, and of the volume average of containment boundary components, in order to help to explain the temperature trends of Figure 3.4.1(a).

(3) It is noted that Section 3.4.3.2 (and page 3-5 of the application stated that “the maximum cask cavity average temperature under the fire condition is conservatively overestimated by adding 160°C (320°F) to that under the normal conditions”.

The applicant shall provide a calculation and justify that adding 160°C to the cask cavity normal conditions of transport temperature provides a bounding cask cavity temperature during the hypothetical accident thermal conditions.

In addition, recognizing that (i) the decay heat and content were modeled during the fire thermal condition (and, therefore, should have temperatures associated with it, per Section 3.4.1), and (ii) the thermal hypothetical accident condition model accounts for damage that is not included in the normal conditions of transport model, the staff notes there was no discussion for needing to use normal condition temperatures (i.e., adding 160°C).

It is also noted that internal temperatures have an impact on the seal temperature at the hypothetical accident condition, and therefore, accurate and/or bounding temperatures are needed.

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

Holtec’s Response to RAI 3-1:

(1) Considering the updated calculations and reporting of the temperatures in the SAR, responses are provided here insofar as the questions pertain to proposed revision 3 of the SAR.
In Rev. 2 of the SAR, in Table 3.1.2, the maximum temperature of the inner seal was reported. In contrast, bulk averaged temperatures were reported for thick components like closure lid in Figure 3.4.1 (a) and Table 3.1.2 of the SAR.

The table has been updated since to include both the bulk and local maximum temperatures of the components. The maximum temperature of the closure lid at the end of the 30-minute fire is observed to be 889°F, which indeed is much higher than the maximum temperature of the seal

(531ºF). As the reviewer also noted, this is to be expected as the closure lid is much closer to the fire boundary condition than the seal.

The differences in the results between the Revision 1 of the submittal and the current submittal arises out of two major differences:

a. The maximum inner seal temperature in the current submittal is on par with that reported in the previous submittal. Minor differences are due to design changes such as addition of insulation boards.

b. The current design of the HI-STAR ATB-1T introduces an insulation board between the closure lid and the closure lid dose blocker plate, which partly shields the closure lid from the fire boundary. Hence lower maximum temperatures are observed for the closure lid in the current submittal (909ºF) than in the previous submittal (1130ºF) at the end of the 30-minute fire.

(2) The different components and their relative locations with respect to the fire boundary condition are as described below:

a. Cask Lid: The cask lid [sic], or the "closure lid dose blocker plate," made of stainless steel, is the topmost component of the cask. This corresponds to item 20 in Reference [1]. This component is directly exposed to the fire from above.

b. Closure Lid: The closure lid, made of alloy steel, is part of the containment boundary, right beneath the "closure lid dose blocker plate." This corresponds to item 19 in Reference [1]. An insulation board exists between the closure lid dose blocker plate and the closure lid. This component is, therefore, separated from fire by the insulation board as well as the closure lid dose blocker plate.

c. The outer dose blocker plates (side, bottom, end, and corner) are made of stainless steel. These correspond to items 9, 10, 11, and 12. These components are directly exposed to the fire.

d. The containment walls (side and end), made of alloy steel, are part of the containment boundary on the sides of the cask. These correspond to items 2 and 3 in Reference [1]. These are surrounded by the side, end, and corner outer dose blocker plates on the outside, which separate the containment walls from the fire boundary condition.

e. The containment baseplate, made of alloy steel, is part of the containment boundary on the bottom. This corresponds to item 1 in Reference [1]. This is directly above the intermediate dose blocker plate.

(3) The reviewer is correct that the cask internals are modeled during both normal and fire conditions. However, there is a difference in how the cask cavity is modeled between the normal and fire accident conditions. Due to uncertainty in the orientation of the waste and BFA tank positions after a drop accident, the approach described in the SAR (Section 3.4.3.2) is adopted since it is conservative, as explained next.

The internals of the containment boundary components form the cask cavity. The rise in the bulk averaged temperatures of a cask component due to the fire boundary conditions decreases with the increase in distance from the surface directly exposed to fire, since the heat flux due to the fire flows outside-in. This means that the rise in bulk average temperature of the cask cavity will be lesser than that of the containment boundary components. The rise in the bulk average temperature of the containment boundary, which immediately surrounds the cask cavity, is purported to be the upper bound for the rise in the bulk average temperature of the cask cavity. The maximum rise in the bulk average temperature of the containment boundary is 154°C (277F), obtained by taking weighted average of rises in bulk average temperature of closure lid and containment walls reported in Table 3.1.2. As a slight conservatism, this is rounded up to 160°C and is used to evaluate the maximum pressure in the cask cavity.

For further demonstration, the maximum rise in the cask cavity average temperature due to fire accident is post-processed from the FLUENT files and is approximately equal to 96°C, which is well below the 160°C adopted in the SAR. This could have been adopted to calculate the peak cask pressure under fire accident condition. However, the approach adopted in the SAR is conservative as explained above.

Reference [1]: Holtec Drawing No. 9786, Revision 6.

NRC RAI 3-2:

Clarify the surface temperature of the package after the 30-minute fire to ensure the boundary conditions for subsequent analyses are appropriate.

A review of the T200-half-uniform-1d75kw-fire-initial.cas file appeared to show an approximately 388°C external surface temperature 30 minutes after the start of the fire. This is different from expected temperatures, considering that the surface had been exposed to an 800°C fire for 30 minutes and Figure 3.4.1 from the previous application (Revision 1) reported temperatures over 750°C.

It is also noted that final boundary conditions after the 30-minute fire are applied as input for the subsequent cooldown transient analysis (including determining seal temperatures), and therefore, appropriate inputs are necessary.

Recognizing the uncertainty in the temperature above and the presence of oscillatory-like swings at the end of the energy balance residual plot (T200-half-uniform-1d75kw-fire-initial.cas), the applicant shall demonstrate and clarify that the hypothetical accident condition thermal results have reached convergence (e.g., monitoring seal temperature throughout the timesteps) to ensure that reported values are representative.

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

Holtec's Response to RAI 3-2:

Considering that the calculations have been updated, the response below is based on the calculations performed in support of the proposed revision 3 of the SAR and Rev. 3 of HI-2156585.

For the sake of clarity, a brief description of the various components is provided below:

Item number(s) in the drawing (Reference [1])	Component(s) (corresponding zone in the Fluent files)
11, 12	Outer dose blocker side and end plates (outer-dsb)
20	Closure Lid Dose Blocker Plate (dsb-closure-lid)
11, 12	Outer dose blocker side and end plates (outer-dsb-cask)
9	Outer Dose Blocker Bottom Plate (outer-dsb-bot-plate)
10	outer-dsb-corner-plate-undamaged

It is to be noted here that the containment boundary components, whose temperatures have been reported in Table 3.1.2 of the SAR, are not directly exposed to the fire boundary conditions. All the components exposed to the fire boundary conditions in the thermal model are listed in the table above. Neither in Figure 3.4.1 of the previous revisions nor anywhere in the proposed revision 3 of the SAR have the temperatures of the components listed in the above table been reported. The external surfaces of the cask that are directly exposed to the fire indeed show a maximum temperature of 662^{o}C (1224^{o}F), which is in line with the reviewer's comments.

There seems to be no inconsistency between expectations and results at the end of the 30-minute fire. Since the solution at the end of the 30-minute fire serves as the initial condition for the post-fire evaluation, therefore, the model used as initial condition is also appropriate for the post-fire analysis.

The transient fire evaluation is performed until all the containment boundary components reach their respective peak temperatures and start to recede. That is, the calculations are not extended until the closure lid seal temperature reaches an asymptote. This is because the maximum temperatures is already computed soon after 30 minute fire ends. The transient calculations are performed with large number of iterations per every time step which results in atleast 3 to 4 orders of drop in energy residuals as shown in Figure 1. Additionally, the converged mesh is adopted for the transient simulation to compute the closure lid seal temperatures.

Reference [1]: Holtec Drawing No. 9786, Revision 6.

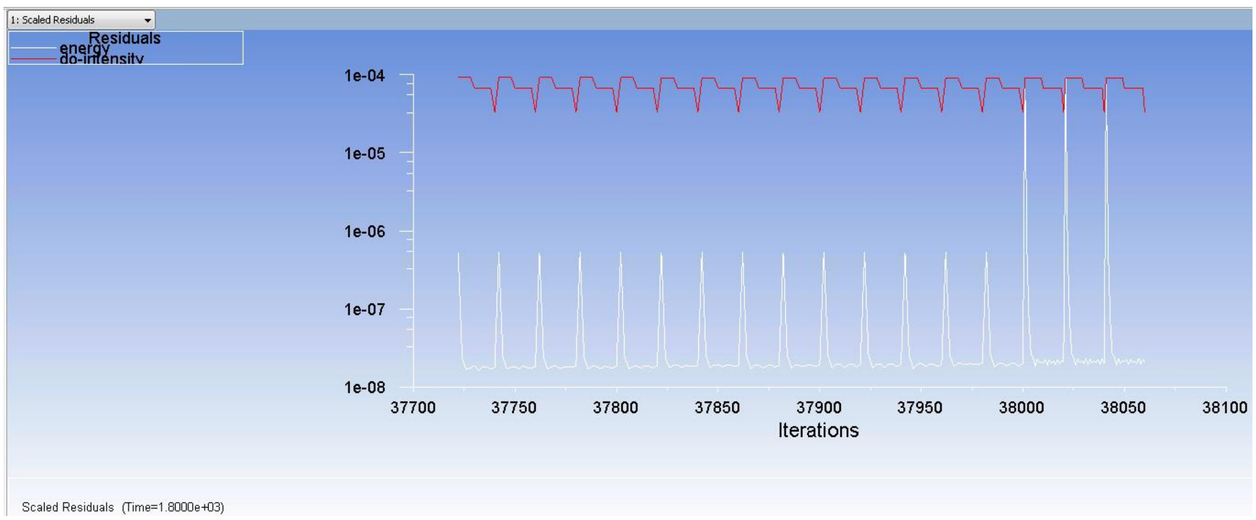


Figure 1: Plot of residuals at the end of the 30-minute fire (previous 200 iterations plotted for clarity):

NRC RAI 3-3:

Justify the appropriateness of a 0.11 emissivity value in the thermal analyses and that a polished surface can be maintained during both normal conditions of transport and hypothetical accident conditions.

Table 3.2.5 of the application includes a new "polished stainless steel" material with an emissivity of 0.11. However, a description and use of this material is not clearly discussed in the thermal analysis.

In addition, the appropriateness of the 0.11 value was not justified, recognizing the difficulty in maintaining a polished surface.

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

Holtec's Response to RAI 3-3:

To provide additional margin in controlling the maximum seal temperature during postulated post-accident fire analysis, a polished surface had been specified on the interior, upper corners of the cask. This was a conservative measure intended to enhance the cask's effectiveness during accident scenarios.

Subsequent changes to the cask design have since been made to eliminate plastic strain in the seal region, which include eliminating the stainless steel inserts at the cask and lid corners. As a result of eliminating the stainless steel inserts and replacing this material with alloy steel in the structural evaluation model, the conservatism of the polished stainless steel surfaces in the heat transfer evaluation model has been likewise eliminated. The use of a surface emissivity of 0.85, in line with assumptions made for all other painted surfaces for alloy steel in the cask, has demonstrated maximum temperatures at the seal location that are equivalent to that predicted by the earlier model with polished surfaces. This is made possible by the combined effects of this and other structural design changes, which both eliminate plastic strain in the seal region and reduce predicted material damage during the analysis of the accident condition of a free drop onto the upper cask corner followed by a localized puncture in the same region. This was the most challenging condition for maintaining the seal temperature during the fire accident, and the reduction in material damage has a significant effect on local conductive heat transfer from the outside of the cask to the seal region, allowing the use of higher emissivity assumptions on the radiating surfaces at the cask corner. The requirement for a polished surface per Flag Note 2 of licensing drawing 9786 has therefore been removed. Thus, the question of maintaining the emissivity of a polished surface in this region is no longer relevant.

Reference [1]: Holtec Drawing No. 9786, Revision 6.

NRC RAI 4-1:

Justify that the release calculations presented in Chapter 4, and corresponding allowable leakage rate, are appropriate considering the condition of the seal and closure region of the containment boundary during hypothetical accident conditions.

According to Figure 8.5 and Figure 8.5.7 (Document HI-2177539), there is separation of the lid from the flange beyond the gasket's springback for an unspecified perimeter length.

In addition, plastic deformation in the closure region is observed in the LS-DYNA results for many of the analyzed drops. The closure's performance would affect the potential release beyond that analyzed in Chapter 4.

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

Holtec's Response to RAI 4-1:

Response to the first part of the question "**Justify that the release calculations presented in Chapter 4, and corresponding allowable leakage rate, are appropriate considering the condition of the seal and closure region of the containment boundary during hypothetical accident conditions.**

According to Figure 8.5 and Figure 8.5.7 (Document HI-2177539), there is separation of the lid from the flange beyond the gasket's springback for an unspecified perimeter length."

Under a certain drop accident simulation, the containment lid/flange geometry yield unloading of the lid seals in excess of the seal worthiness compression for a short duration of time. To evaluate potential leakage a physical gap is conservatively postulated beyond the threshold compression and gas leakage computed. It is shown that an upper bound activity release under drop event is well below the 10CFR71.51(a)(2) accident limit. Additional discussion is provided in a new paragraph 4.4.2.7 of the HI-STAR ATB 1T SAR. Conclusion in paragraph 4.4.2.6 are updated to reflect revised calculations. Details of the calculations are provided in containment calculation package HI-215669, with corresponding calculations presented in a new Attachment C of the containment calculation package.

Response to the second part of the question **"In addition, plastic deformation in the closure region is observed in the LS-DYNA results for many of the analyzed drops. The closure's performance would affect the potential release beyond that analyzed in Chapter 4."**

Holtec Response:

Design improvements have been implemented in the revised package design to limit the impact loads and to eliminate the inelastic strains in the primary sealing area and maintain stresses below the material yield strength. To this effect, all the critical HAC drop simulations are revised in the proposed Revision 3 of the SAR, and it is demonstrated that the stresses in the primary sealing region are well within the material yield strength of the seal seating surfaces.

For some critical HAC drop orientations, local material yielding resulting in small inelastic strains is observed away from the primary seal seating region (i.e., containment seal grooves), which is determined to be acceptable since it has no adverse impact on the form, fit or function of the containment boundary seal.

NRC RAI 4-2:

Specify the inner and outer seal locations in drawing 9786 Rev. 5 (sheet 4 of 7) and clarify that the inner and outer seals are correctly positioned in the LS-DYNA models/results provided in the application.

The performance of the containment boundary seals is dependent on its position within the closure lid. However, the seal's relative position within the lid is not defined in the drawings.

In addition, there is an uncertainty in the strains and loads bn the seals within the reported LS-DYNA model results during hypothetical accident condition modeling scenarios because of the uncertainty in the seal's position.

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

Holtec's Response to RAI 4-2:

The BOTTOM VIEW of Sheet 4 of drawing 9786 shows the location of the inner seal, and DETAIL 4B on the same sheet shows the location of the outer seal in relation to the inner seal. These dimensions effectively define the seal locations. To make the location of the seals clearer, an additional dimension from the outer edge of the lid to the inner seal has been added to DETAIL 4B in Revision 6 of the drawing.

While the seals are not explicitly modeled in LS-Dyna simulations, the seal grooves are modeled per the dimensions shown on the dwg. The primary seal seating groove on the closure lid and the underlying elements (primary seal seating area) on the containment walls represent the primary sealing region. For evaluation purposes, the seal weld overlay (seal seating) surfaces overlapping with the primary seal groove are shown to remain inelastic (no plasticity). In addition, the seal opening subsequent to the drop event is shown to remain below the seal useful (allowable) spring back. Instantaneous seal opening beyond the seal useful (allowable) spring back is evaluated as part of the containment evaluation.

The LS-Dyna finite element model considers the containment seal region consistent with the dwg. and is appropriately evaluated for the safety compliance as discussed in subsection 2.1.2 of the SAR.

NRC RAI 4-3:

Provide the closure's surface condition (e.g., RA, RMS and units) for the contact surface between the flange and closure lid, including the weld overlay and the 0-ring grooves.

The sealing performance of an 0-ring is dependent on surface condition (per page 7-4 of the application), but surface condition specifications were not found in the drawings (e.g., 9786 Sheet 4 of 7, Rev. 5).

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

Holtec's Response to RAI 4-3:

To specify the surface condition of the o-ring grooves and sealing surfaces, Flag Note 7 has been revised in Revision 6 of licensing drawing 9786 to state the following:

> WELD OVERLAY MATERIAL AT O-RING GROOVES AND SEAL SEATING SURFACES TO BE INCOLOY 945 UNS N09945. ALTERNATIVE HIGH STRENGTH WELD OVERLAY MATERIAL MAY BE USED WITH A MINIMUM YIELD STRENGTH EQUAL TO OR GREATER THAN INCOLOY 945. SURFACE FINISH OF O-RING GROOVE SHALL BE 125 MICRO-INCH Ra OR BETTER. SURFACE FINISH OF SEAL SEATING SURFACE SHALL BE 63 MICRO-INCH Ra OR BETTER.

NRC RAI 5-1:

Provide justification for the mesh size of the tallies for the trunnions, the closure lid lift lug holes and the chamfered cask edges.

The applicant provides the sizes of the tallies in Table 3 of Enclosure 10: Shielding Analysis for the HI-STAR ATB 1T, HI-2156583 Rev. 4 to the application (ADAMS Accession No. ML19158A519). Section 5.1.3 of the application states: *"In normal conditions models, tallies are present adjacent to the chamfered edges of the cask and adjacent to lift lug holes to ensure any local dose rate maximums are considered in these areas with localized steel through-thickness reductions."*

Since the purpose of these tallies is to account for localized reductions in shielding, the tally sizes should be sufficiently small to detect these local effects. However, from Table 3 of Enclosure 10, it appears that the tally sizes may be too large to capture the details of the potential hot spot(s) in the weak shielding area.

The staff requests that the applicant justify that the mesh sizes of the tallies, designed to account for local effects, are appropriate for capturing the maximum dose rate.

This information is required to determine compliance with 10 CFR 71.47(b).

Holtec's Response to RAI 5-1:

MCNP input files for normal conditions of transport have been updated with reduced tally size, more conservative tally dose point locations, and more conservative cask geometric modeling. Dose rate results have been updated in Tables in Sections 5.1 and 5.4 of the HI-STAR ATB 1T SAR Proposed Revision 3. Specifically, trunnion geometry has been conservatively updated so that the protrusion of the trunnion from the main body of the HI-STAR ATB 1T cask is not modeled under normal conditions. Trunnion tally geometry is updated in Figure 5.3.2 of the HI-STAR ATB 1T SAR Proposed Revision 3. Closure lid lift lug holes in the MCNP model do not credit the steel material that protrudes beyond the main closure lid surface of the HI-STAR ATB 1T cask, and the tally is positioned in the most conservative location, recessed into the closure lid lift lug hole, as shown in updated Figure 5.3.12. Table 3 of HI-2156583R5 is updated to reflect the updated smaller tally sizes and several notes (attached at end of response, below), are placed below Table 3 in the HI-STAR ATB 1T Calculation Package (HI-2156583R5) regarding MCNP tally geometry adjacent to trunnion, closure lid lift lug hole, and chamfered edge.

Additionally, two tables that provide trunnion, lift lug hole, and chamfered edge localized, maximum surface and 2 meter dose rates (Tables 5.4.6 and 5.4.7) are included in the updated HI-STAR ATB 1T SAR Proposed Revision 3.

Tables 5.4.6 and 5.4.7 demonstrate that localized, normal conditions, maximum dose rates near the trunnions, closure lid lift lug holes, and chamfered edges of the cask, for all waste package types, have substantial margin as compared to transportation dose rate limits in 10 CFR 71.47(b).

HI-2156583R5 HI-STAR ATB 1T Shielding Calculation Package, Table 3, (Added Notes):

"Note 1. Trunnion Tallies

Trunnion portion that extends beyond the outside surface of the cask is conservatively not modeled under normal conditions. Surface tally (Cell 480) located adjacent to the truncated trunnion that forms a ring around the trunnion has an outer diameter of 15 cm, and an inner diameter of 5 cm and a thickness of 1 cm. This tally is segmented into two parts that make up "half rings" immediately adjacent to the trunnion, and conservatively does not credit the material nor the distance the trunnion protrudes beyond the outermost main body cask surface. The second surface tally (Cell 490) is also immediately adjacent to the truncated trunnion, and conservatively does not credit the material nor the distance the trunnion protrudes beyond the outermost main body cask surface and has a diameter of 5 cm and a thickness of 1 cm. There is a 2 meter tally (Cell 492) at the same axial height as the trunnions with a diameter of 15 cm, and a thickness of 1 cm.

Note 2. Closure Lid Lift Lug Hole Tallies

The lift lug holes are approximately 15 cm in diameter. The surface tally (Cell 493) above the lift lug hole is 5 cm in diameter and 1 cm thick axially. Some steel material that constitutes the lift lugs that protrude above the main top surface of the HI-STAR ATB 1T cask, is conservatively not credited in the MCNP models. The 2 meter tally (Cell 560) directly above the lift lug holes is 15 cm in diameter and 1 cm thick axially.

Note 3. Chamfered Edge Tallies

The surface tally (Cell 440) and 2 meter tally (Cell 540) along the side mid-height of the chamfered edge of the HI-STAR ATB 1T cask have diameters of 5 cm and axial heights of 20 cm. The chamfered edge tallies at the surface and 2 meters, like other side mid-height tallies, are aligned with the axial mid-height of the homogenized source region. The chamfered edge runs the full height of the HI-STAR ATB 1T cask from bottom to top. Impact absorbing material present along the chamfered edge of the cask is conservatively not credited.

Note 4. Additional tally location information and explanation is present in the HI-STAR ATB 1T SAR [2], Subsections 5.1.3 and 5.4.4."

NRC RAI 5-2:

Update the Drawings and Chapter 7 of the application to clearly state the BFA Tank Configurations, when not using the BTC, for the various waste container types.

Section 1.1 of the application states that the BFA Tank Cassette (BFC) is an optional component. This section states, *"If the optional BTC is not used, equivalent material shielding thickness is provided by commensurately increasing the BFA-Tank top cover and bottom plate thickness."*

The staff requests that the applicant updates the drawings of the BFA-Tank to show the alternate BFA-Tank configuration. The staff also requests that the applicant updates Chapter 7 of the application to clearly show that the BFA Tank and BTC are required or show that the alternate BTC configuration, with the increased thickness, is required for the various Waste Package Types. The loading procedures, for loading without the BTC, shall also be updated.

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

Holtec's Response to RAI 5-2:

As the use of the optional configuration of waste packaging without a BTC is not a necessity for this licensing submittal, Holtec has chosen to simplify the application and review process by removing this configuration as an option.

Specifically, Additional Note 1 of licensing drawing 9876 (Sheet 1) is revised to state the following:

> BFA-TANKS AND CASSETTE TYPES ARE DESIGNATED T-50, T-100, T-150 AND T-200. EACH BFA-TANK IS USED WITH ITS CORRESPONDING CASSETTE TYPE TO ACHIEVE THE REQUIRED TOTAL SAFETY-RELATED SHIELDING MATERIAL THICKNESS.

This removes all references to the optional use of a BFA-Tank without its corresponding BTC from the licensing drawings. Similarly, references to this optional loading configuration are removed throughout the SAR.

NRC RAI 5-3:

Provide an analysis demonstrating that the package meets the NCT dose rates in 10 CFR 71.47 when the side trunnions have failed and are removed from the package.

The trunnions on the side of the package are currently credited as part of the shielding of the package when evaluating the package's ability to meet NCT dose rate limits as shown in Figure 5.3.2 of the application.

As discussed in Section 5.4.4 of the application, the applicant has evaluated whether the shielding of the package is adequate to meet HAC dose rate limits in 10 CFR 71.51(a)(2) assuming the trunnions have failed and are removed from the package; however, the requirements in 10 CFR 71.45(a) are not specific to HAC and state that *"failure of any lifting device under excessive load would not impair the ability of the package to meet other requirements of this subpart"* which includes NCT dose rate limits in 10 CFR 71.47.

This information is required, in accordance with 10 CFR 71.45(a), to determine compliance with 10 CFR 71.47.

Holtec's Response to RAI 5-3:

The structural evaluation of failure of lifting devices is presented in Paragraph 2.5.1.3 of the HI-STAR ATB 1T SAR, which is excerpted below:

> 2.5.1.3 Failure of Lifting Devices
>
> 10CFR71.45 also requires that the lifting attachments permanently attached to the cask be designed in a manner such that a structural failure during lifting will not impair the ability of the transportation package to meet other requirements of Part 10CFR71. The ultimate load carrying capacity of the lifting trunnions is governed by the cross section of the trunnion external to the cask rather than by any section within the cask. Loss of the external shank of the lifting trunnion will not cause loss of any other structural or shielding function of the HI-STAR ATB 1T cask; therefore, the requirement imposed by 10CFR71.45(a) is satisfied.

The normal conditions of transport MCNP HI-STAR ATB 1T shielding models have been conservatively updated to consider loss of the trunnion external to the cask main body surface as shown in updated Figure 5.3.2 of the HI-STAR ATB 1T SAR Proposed Revision 3. Dose rates at the surface and 2 meters from the “failed” trunnion under normal conditions of transport for each Waste Package Type are presented in the new Tables 5.4.6 and 5.4.7, respectively, and demonstrate compliance with 10 CFR 71.47.

NRC RAI 7-1:

Clarify how the lift points of the package will remain inoperable during transport.

Chapter 7 does not mention when lifting points will be rendered inoperable during transport as per the regulations. Clarify and/or update the application, as necessary.

This information is required to determine compliance with 10 CFR Part 71.45(a).

Holtec's Response to RAI 7-1:

The lift points of the package are rendered inoperable during transport by the installation of the weather protection cover (WPC), described in Step 5 of Subsection 7.1.4 of the SAR application. This is accomplished by:

1) Securing the WPC to the waste package by direct attachment to the cask lifting trunnions, so that they are not capable of being engaged by a lifting device;
2) The presence of the WPC itself, which, by virtue of its coverage of the entire top surface of the cask, prevents overhead access to the lifting trunnions required for engagement of a lifting device.

To better describe this function of the WPC, Step 5 of Subsection 7.1.4 (Preparation for Transport) is revised to state:

> *The WPC is installed on the cask and transport frame. The installed WPC is secured to the cask lifting trunnions, rendering them inoperable for lifting the cask.*

And a Step 5 is added to Subsection 7.2.1 (Receipt of Package from Carrier) to state:

> *The WPC is removed from the cask to allow access to the cask lifting trunnions for lifting the cask.*

The description of package loading (Section 7.1) is also revised to clarify that the WPC must be installed prior to cask shipment, and is not optional.

NRC RAI 7-2:

Clarify either in the application or in the licensing drawings when the security seal is inspected for tampering and removed during unloading operations.

Section 1.2.1.8 of the application discusses the security seal that is used to indicate when the package has been opened by non-authorized persons. However, in the package operating procedures section, it is not mentioned when the seal is examined and removed from the package.

This information is required to determine compliance with 10 CFR 71.43(b).

Holtec's Response to RAI 7-2:

The operation to inspect and remove the security seal is added to the SAR application as Step 4 of Subsection 7.2.1, as follows:

> *The security seal is verified to be intact, to ensure that the package has not been opened by unauthorized persons. Following verification, the security seal is removed.*

NRC RAI 7-3:

Clarify the torque of the bolts used to secure the BFA-Tank lid and designate them as ITS on the drawings.

Section 7.1.2.1 of the application on page 7-5 indicates that the BFA-Tank has bolts which secure the lid to the rest of the BFA-Tank. The torque values don't appear to have been specified in the licensing drawings or in any submitted calculations.

The bolts prevent the lid from separating from the BFA-Tank during free drop and puncture accident scenarios and therefore are ITS rather than denoted as NITS. The applicant states that lid and sidewall separation is not permitted according to Calculation 5 of document HI-2177540R2. Update the licensing drawings and calculations as necessary.

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

Holtec's Response to RAI 7-3:

Additional analysis has been provided, as described in the response to RAI 2-5, establishing the structural criteria related to ensuring that the BFA-Tank lid does not separate from the sidewalls during free drop and puncture accident scenarios. The analysis does not require a bolt pre-load to preclude separation that would affect the safety-related configuration of the BFA-Tank assembly. An applied torque value for the BFA-Tank bolts is therefore not required. As stated in Step 8 of Subsection 7.1.2.1 and Step 1 of Subsection 7.1.2.2, the bolts are installed "wrench-tight", meaning the force applied by a single person using a suitably sized tool (wrench) without any additional force multiplier (for example, the use of a cheater bar or similar). This force is specified as a precaution to ensure bolts remain engaged during normal handling and transport. Step 3 of Subsection 7.1.2.2 adds the additional provision that BFA-Tank lid bolts shall be installed as recommended by the BFA-Tank supplier, as the supplier may suggest additional torque requirements related to BFA-Tank assembly for operational reasons that are not applicable to the safety-related function of the BFA-Tank.

The bolts are now considered ITS components based on the additional analysis described in the response to RAI 2-5.

To reflect the specific acceptance criteria for these bolts, using a generalized approach that encompasses all manufacturing differences between BFA-Tank designs that may vary in detail between various suppliers and various versions already in existence, licensing drawing 9876R8 is revised by adding a flag note stating the following:

NUMBER OF BOLTS ATTACHING TOP COVER TO BFA-TANK MAY VARY. A MINIMUM OF TWELVE (12) BOLTS SPACED AROUND THE PERIPHERY OF THE TOP COVER ARE REQUIRED. BOLTS TO BE FABRICATED FROM STEEL WITH A MINIMUM TENSILE STRENGTH OF 830 MPa (120 ksi). THE MINIMUM COMBINED CROSS-SECTION AREA OF ALL BOLTS SHALL BE 5.25 SQUARE INCHES FOR THE T-50 BFA-TANK, AND 10.25 SQUARE INCHES FOR ALL OTHER BFA-TANKS. THE NOMINAL THREAD ENGAGEMENT OF EACH BOLT SHALL BE ONE INCH OR GREATER.

In this note, the combined bolt area and minimum tensile strength are specified as the minimum required to preclude bolt shear, per Calculation 5 of document HI-2177540R3.

Drawing 9876R8 is also revised to specify the BFA-Tank bolts as ITS.