NRC RSI 1-1:

Clarify the amount of plutonium that will be transported by the Model No. HI-STAR ATB 1T package.

Page 1-17 of the application indicates that a small amount of plutonium may be transported. Table 7.1.2 is reported to have the quantities of plutonium but such information could not be found in the table.

This information is needed by the staff to determine compliance with 10 CFR 17.33 and 71.63.

Holtec's Response to RSI 1-1:

We apologize for the confusion due to the wording of the paragraph in Subsection 1.2.3. The intent of Subsection 1.2.3 is to address 10 CFR 71.63 "Special requirements for plutonium shipments", which states that "Shipments containing plutonium must be made with the contents in solid form, if the contents contain greater than 0.74 TBq (20 Ci) of plutonium." To clarify, Subsection 1.2.3 (page 1-17) of the HI-STAR ATB 1T SAR has been revised as follow: "The contents of the package, provided in Section 1.2.2 and to be transported in the HI-STAR ATB 1T Package may contain plutonium in solid form." A paragraph has been added to Subsection 1.2.2 that states "Fissile material and SNM as defined in the glossary of this SAR and meeting the requirements of Subsection 1.2.3 and Table 7.1.2 are authorized contents for the HI-STAR ATB 1T. For simplicity, all SNM is assumed to be fissile material and counts towards the maximum permissible quantity of fissile material in Table 7.1.2. The majority of fissile material and SNM is expected to be within the Crud and contamination on the surfaces of the activated metals." The maximum quantity of fissile material in Table 7.1.2 has been revised to include SNM.

The contents of the HI-STAR ATB 1T is described in the SAR as non-fuel waste, more specifically reactor-related waste (a.k.a core components). Examples are provided in SAR Section 1.2.2; therefore, the amount of plutonium of any kind will typically be trace quantities much less than 0.74 TBq (20 Ci).

Notwithstanding, the total mass of plutonium, when combined with the masses of other fissile materials in the package, shall comply with the fissile materials mass limit in Table 7.1.2.

NRC RSI 1-2:

Provide center of gravity information for the Model No. HI-STAR ATB 1T package for all package configurations.

Page 5 of 15 of the document titled "Structural Calculation Package for HI-STAR ATB 1T" indicates that center of gravity information for the package has been provided in Table 1.1.1 of the application. However, this information appears to be missing from the table.

This information is needed by the staff to determine compliance with 10 CFR 71.33 and 71.45.

Holtec's Response to RSI 1-2:

The "Structural Calculation Package for HI-STAR ATB 1T" inadvertently referenced the center of gravity (C.G.) in lieu of the cask/package weight in Table 1.1.1. The "Structural Calculation Package for HI-STAR ATB 1T" has been updated to reference Table 7.1.1 of the SAR for weight information.

NRC Observation 1-3:

Indicate on the licensing drawings what welding process, weld filler material, and welding notes/inspection method will be used at each of the welds specified on the plans along with associated welding calculations.

Base material welding calculations have been provided in the application, but the welds calculations themselves have not been. Weld filler material and welding process have not been provided either. Reference to the ASME codes alone is insufficient.

This information is needed by the staff to determine compliance with 10 CFR 71.45, 71.71, and 71.73.

Holtec's Response to Observation 1-3:

To address this observation, flag note 3 on licensing drawing 9786 (HI-STAR ATB1T CASK) is changed to:

"Welds are designated in the following categories. Refer to additional note 5 for applicable welding and inspection requirements for containment boundary and dose blocker / structural welds. All welds shall be visually inspected.

a. Containment Boundary Weld
b. Dose Blocker / Structural Weld
c. Non-code/NITS Weld"

All welds reference flag note 3, which indicates whether they are CONTAINMENT BOUNDARY, DOSE BLOCKER / STRUCTURAL or NON-CODE welds (STRUCTURAL has been changed to DOSE BLOCKER / STRUCTURAL in the revised note, for clarity and consistency). The welding and inspection procedures/acceptance criteria for CONTAINMENT and DOSE BLOCKER welds are specified in note 5. All welds will be visually inspected, which has been added to the note.

Section 2.2.3 of the SAR states: "All weld filler materials utilized in the welding of the Code components will comply with the provisions of the appropriate ASME Code Subsection (e.g., cited paragraphs of Subsection NB and with applicable paragraphs of Section IX). All non-Code welds and non-Metamic-HT welds will be made using weld procedures that meet ASME Section IX, AWS D1.1, D.1.2 or equivalent. The minimum tensile strength of the weld wire and filler material (where applicable) will be equal to or greater than the tensile strength of the base metal listed in the ASME Code." The weld filler material (AWS E308L for all stainless-to-stainless welds) which is added to the table in additional note 5 is consistent with this statement.

Licensing drawing 9876 (BFA Tanks and Cassettes) is also revised to specify the weld filler material strength as "of equivalent or greater strength than the base material" for all structurally significant welds.

(NOTE: Accidental reference to Metamic-HT in Section 2.2.3 is corrected in revised SAR).

<u>NRC Observation 1-4</u>:

Clarify what is meant by better mechanical properties with respect to the general notes on drawing sheet 1 of 5.

Generate note E on drawing sheet 1 of 5 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 or better 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."

It is unclear what constitutes "better" mechanical properties. Selecting a raw form with higher yield stress may be viewed as "better" but may have less ductility, which can affect the energy dissipation characteristics of the package. In addition, describe what tests will be performed in this case. Stating that tests shall be in accordance with ASME Code is insufficient.

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

<u>Holtec' Response to Observation 1-4</u>:

To address the concern that alternate product forms may have different material properties that are not necessarily "better" for the applications in question, the drawing parts list is revised (where relevant) to include all ASME or ASTM designations and product forms that have been identified for each ITS component in the cask design. In general, the product forms specified have identical chemical composition and mechanical properties. However, wherever this is not the case, the cask analysis (thermal, structural, shielding) includes evaluation of the effect of any differences.

Note E is a standard note intended to allow fabrication flexibility in the specification of product forms (as it states) if properties are identical. To remove the ambiguity that the standard note creates with the use of the word "better", the note on both licensing drawings 9876 and 9786 are revised as follows (deletion shown by strikethrough): "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 ~~or better~~ 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."

NRC Observation 1-5:

Clarify what components could be possibly fabricated from multiple pieces.

Note 4 of sheet 1 of 5 of the drawings indicates: "Parts may be made of multiple pieces provided acceptable safety factors are maintained." It is unclear what safety factors will be maintained, and their amount. Provide details indicating what pieces will be fabricated from multiple pieces, how these separate pieces will be joined, and what dimensions these pieces will have. Coordinate this note on the drawings as it applies to what is mentioned on page 2-25 of the application which states: "The Top Flange and the Closure Lid are monolithic sections."

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

Holtec's Response to Observation 1-5:

To clarify this statement for this particular design, note 4 will be replaced with a flag note (#6) applied only to the closure lid (ITEM 8) and top flange (ITEM 2). Note shall state:

"To improve fabricability, parts may be made of multiple pieces joined by full-penetration welds that provide strength equivalent to the base metal."

Weld joint preparation will not be specified on the drawing for the full-penetration welds. For the specified parts, using full-penetration welds, the weld joints may be at any location and are therefore not specified on the licensing drawing.

NRC Observation 1-6:

Justify the permission of oversized and undersized welds in the package.

Note 2 on page 1 of 5 of the drawings states that: "All structural weld sizes are minimum values; larger welds may be specified on the fabrication drawings as long as they do not create any interference or excessive deformation issues. Local areas of undersize weld are acceptable within the limits specified in the applicable Holtec standard procedure."

Welds must be as per the standard to which they are specified, and to the size specified on the drawings. Welds smaller than those specified are not acceptable.

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

Holtec's Response to Observation 1-6:

To avoid the issue of defining limits to undersized welds in the licensing drawing, the caveat for "local areas of undersized weld" is removed from the licensing drawing.

NRC Observation 1-7:

Clarify the tolerances provided on the licensing drawings.

Note F on page 1 of 5 of the licensing drawings states that: "Dimensions without tolerances are nominal values. Dimensional tolerances on this drawing are provided solely for licensing purposes to define limits on dimensions used in licensing basis analysis. Hardware is fabricated in accordance to ensure with the fabrication drawings, which have tolerances appropriate to ensure component fit-up. Do not use worst case tolerance stack-up from this drawing to determine component fit-up. Dimensions indicated as "reference" are subject to tolerance stack-ups; dimensions indicated as "nominal" will vary in the manufactured hardware to the extent typical in applicable fabrication operations (such as rolling, plasma cutting and machining). Dimensions indicated as minimum or maximum are considered to be controlling dimensions."

It is unclear what the tolerances are for the package components despite this note. Tolerances for all parts of the package that are important to safety should be specified in a clear manner. Additionally, it is unclear how tolerance stack-up is not possible for some parts while being possible for others.

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

Holtec's Response to Observation 1-7:

Holtec has reviewed ISG-20, NUREG/CR 5502 and NUREG 1609/1617 for guidance in evaluating the tolerances required for inclusion in this licensing drawing. In general, each guidance document states that design features that are credited in analyses and important to safety be toleranced where appropriate to support the licensing basis.

Past internal Holtec practice has been to require all toleranced dimensions shown on licensing drawings to be inspected as critical dimensions on fabrication drawings, to provide assurance of compliance with the licensing basis. As such, only key dimensions where variation within tolerances must be tightly controlled have been specified in licensing drawings. Dimensions where variation within normally accepted fabrication practices do not impact the safety of the component (e.g. design features with large safety factors or insensitivity to dimensional variation) are left as nominal untoleranced dimensions in the licensing drawings, to provide emphasis to the toleranced dimensions and ensure their compliance during fabrication.

The drawing is currently being reviewed for compliance with the above mentioned guidance and dimension tolerances will be added to fully support the licensing basis assumptions. It should be noted that dimensional tolerances specified in this way are likely to exceed, in some cases, those required for the actual manufacture and fitup of components during fabrication. Tolerances shown on the licensing drawing should therefore not be used for stackup evaluation or determination of the fitup of components. Components specified as "stock" items with recognized tolerance standards (such as plate, pipe, etc.) will reference those tolerance standards, unless tighter dimensional restrictions are required.

For clarity, note F shall be changed to:

"Dimensional tolerances on this drawing are provided solely for licensing purposes to define limits on dimensions used in the licensing basis analysis. Where dimensional variation does not affect the licensing basis, dimensions are shown as nominal values for information. Tolerances appropriate to ensure component fit-up are applied in the fabrication drawings and may differ, without exceeding, the licensing basis tolerances."

NRC RSI 2-1:

Provide additional information to support the benchmarking effort used for modeling the package with respect to the free drop tests specified under normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

The applicant benchmarked physical drop testing of the multi-canister over pack (MCO) package tested by Idaho National Labs (INL) using LS-DYNA in an effort to support the use of LS-DYNA for modeling of the HI-STAR ATB 1T package. The HI-STAR ATB 1T package is rectangular, weighs upwards of 244,000 lb, and has dimensions of approximately 147” x 113” x 71” which is vastly different from the 24” diameter and 14 feet long MCO package tested by INL.

Calibrating a physical test to a model has an advantage that is readily apparent when a model is not behaving properly. Here, the applicant’s LS-DYNA model cannot benefit from physical testing. Without physical testing, the model must be one of “quality”, which currently does not have a quantitative definition. It must be able to accurately capture bolt behavior, plate vs shell behavior, welds that are three dimensional in behavior rather than just two dimensional, etc.

It is still unclear if the model presented in this application can, or cannot, capture this physical behavior. The lid closure mechanism in the ATB 1T has no physical counterpart in the MCO package and it is unclear how it will perform during drop testing. Given this, physical evidence that the model can replicate the physical phenomena expected from a package which has not been physically tested is requested.

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 71.73.

Holtec’s Response to RSI 2-1:

Holtec has undertaken a benchmark test program to support the qualification of the HI-STAR ATB 1T Package. Detailed information is provided in Appendix 2B of the SAR (Revision 1).

NRC RSI 2-2:

Describe the content location within the BFA tanks themselves and their interaction with the package.

A maximum content weight has been provided; however, it is unclear how those contents are distributed within the package along with any dunnage and how they will interact with the package as its mass and center of mass changes.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.71, and 71.73

Holtec's Response to RSI 2-2:

With respect to the BFA-Tank and the BFA-Tank Cassette (BTC) and their interaction with the HI-STAR ATB 1T package, the following approach is considered when evaluating the most limiting free package drop events pursuant with 10CFR71:

1. The package internals viz. the BFA-Tank and the BFA-Tank Cassette (BTC) are represented by distinct bodies consistent with the geometry shown in the licensing drawing in the NCT and HAC drop simulations.
2. The drop simulations considers the bounding weight of the BFA-Tank and the loaded BTC in order to maximize the impact energy. The bounding weight of the loaded BTC is reflected in the simulation model by increasing the density of top and bottom plates of BFA-Tank Cassette.
3. The BFA-Tank and the BTC bodies are largely represented by rigid material with the exception of the 30-ft. top C.G.O.C drop simulation. The corner region of the BFA Tank outer shell is switched to elastic-plastic material for this drop event. This is necessitated to eliminate the unrealistic knife-edge effect on the package containment top flange during the top CGOC drop event. This is a reasonable modeling approach that avoids anomalous local behavior while still maintaining overall conservatism. For all other drop simulations, excluding the top CGOC drop, the BFA-Tank and BTC are modeled as entirely rigid.
4. For the HAC drop simulations, maximum nominal gap is considered between the BFA Tank and the transport package thereby maximizing the impact severity on the containment boundary and the DBS (dose blocker steel) components.

This aforementioned modeling approach ensures that:

a. representing the BFA-Tank and BTC essentially as rigid bodies ensures that there is insignificant energy loss from the contents interacting with each other;
b. representing the BFA-Tank and BTC essentially as rigid bodies also ensures high impulsive loads resulting from the drops thereby by challenging the closure lid and the closure lid sealing;
c. considering the contents attached to the BTC ensures that the total kinetic energy of the contents is acting in unison at the point of impact thereby resulting in maximum damage to the cask containment and the DBS (dose blocker steel) components;

d. for the high energy impulsive events resulting from the HAC drops, the maximum nominal gaps between the BFA-Tank and the cask interior in the direction of impact maximizes the impact severity overestimating the deformation and strains in the cask components.

Moreover, the dynamic response of the package during the direct end, side and C.G.O.C drops is predominantly influenced by the mass of the package, which determines the initial kinetic energy of the package. For these drop orientations, the exact positioning of the center of gravity of the loaded package has only a second order effect on the impact results.

On the other hand, during the transport package slapdown drop cases, the c.g. of the contents may influence the response of the package, particularly during the secondary impacts. However, the secondary impacts of the package during these drops involve significantly larger surface area thereby attenuating the impact severity on the package. The response from these secondary impacts, inherent for the slapdown drop case, is not limiting. This is further substantiated from the drop test results and the slapdown simulation performed in support of this SAR. In summary, the c.g. of the contents has insignificant effect on the package response.

NRC Observation 2-3:

Clarify the package tie-down system (bolts) and transportation frame as being integral to the package or not.

Page 1-11 of the application states: *"The HI-STAR ATB 1T transport cask is engineered for shipment by both waterways and roadways using appropriate supports and restraints. Packaging supports and restraints considered as auxiliary equipment, such as the transport frame and the package tie-down system (bolts) are necessary as part of the transport package. Non-integral appurtenances to the cask, such as the tie-down system and the transport frame are not structural parts of the HI-STAR ATB 1T Package and, as such, are not designated as packaging components."*

It is unclear if the transportation frame and tie down system, as mentioned above, are, or are not, integral appurtenances (structural package components).

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

Holtec's Response to Observation 2-3:

The SAR has been revised to state:

"The HI-STAR ATB 1T transport cask is engineered for shipment by both waterways and roadways using appropriate non-integral supports and restraints, such as the tie-down system and transport frame. Non-integral supports and restraints are not structural parts of the HI-STAR ATB 1T Package and, as such, are not designated as packaging components."

NRC Observation 2-4:

Clarify the initial ambient temperature used for the tests specified under normal and accident conditions of transport.

Ambient temperatures of 100°F to -20°F do not appear to have been examined for the increased external pressure, minimum external pressure, vibration and shock, and 1-foot free drop tests (22°C appears to be examined according to model details). It is unclear how this temperature range affects stresses in the package.

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 71.73.

Holtec's Response to Observation 2-4:

It is correctly noted that the hypothetical accident and normal drop events may occur under the maximum ambient temperature at 38ºC (100°F) or minimum ambient temperature at -29ºC (-20ºF).

Maximum ambient temperature condition: As noted in Table 3.1.1, the HI-STAR ATB 1T package components are subject to hot condition temperatures due to ambient temperature and solar isolation. Accordingly, all the drop events are conservatively evaluated at cask component bounding temperatures. The material stress-vs-strain curves used in the LS-DYNA drop simulations also consider the applicable bounding temperatures for the package components.

Minimum ambient temperature condition: Since the austenitic stainless steels and nickel alloys (the key material of construction for the Package) are highly ductile and not vulnerable to brittle fracture, the consequence of the drop events will be independent of the minimum service temperature of -40ºC (-40ºF). The closure lid locking wedges securing the lid are also made of SB637-N07718 material which is not susceptible to brittle fracture.

This discussion has been added to Subsection 2.6.1 of the SAR (revision 1). Likewise, the external pressure loading condition and vibration analysis used the bounding temperature data in the safety analysis.

NRC Observation 2-5:

Describe the packages performance with respect to drop orientations not described for NCT and HAC.

1.) Describe how the package will perform for HAC and NCT when the package is dropped at shallow angles relative to the end, side, and corner drop configurations mentioned in the application. Note that in the case of the aforementioned corner drop configuration, it is expected that the corner of the long dimension of the package would be directly impacted by slap down effects.

2.) Describe how the package will perform in the side drop configuration mentioned in the application, except that the package has been rotated 45^o relative to its long axis and the corner of the long dimension of the package is struck flush.

This information is needed by the staff to determine compliance with the requirements of 10 CFR 71.71 and 71.73.

Holtec's Response to Observation 2-5:

1) A top down shallow corner drop (a.k.a Top down Slapdown) with an included angle of 16.1 about the shorter edge and an angle of 18 deg. to the longer edge w.r.t to the rigid target is considered in the updated analysis. Moreover, the new slapdown drop simulation considered is consistent with the quarter scale drop angle.

2) Based on the simulations considered earlier in support of this SAR and the resulting decelerations, the package drop over either of the edges is determined to have lesser consequence on the package components in terms of stresses or strains. Therefore, these package drop over the edges are eliminated and replaced with Slapdown and other drops deemed critical for the package performance.

NRC Observation 2-6:

Justify the fatigue endurance of the Model No. HI-STAR ATB 1T package with respect to NCT.

Section 2.6.5 of the application states that stresses encountered during NCT will be small due, in part, to the stiffness of the package. However, it is unclear just how small these stresses are since a more quantitative analysis has not been provided. It has been noted that the corners of the package could be most susceptible to fatigue cracks since three plates are welded at this location.

This information is needed by the staff to determine compliance with the requirements of 10 CFR 71.71(c)(5).

Holtec's Response to Observation 2-6:

Subsections 2.6.5 and 2.6.6 of the SAR have been revised to provide quantitative evidence that the stresses encountered during NCT are small. The fatigue life of the intersecting welds at the corners of the package has also been addressed in the subsections of the SAR.

NRC Observation 2-7:

Describe the performance of the package for the HAC puncture scenario when a trunnion is struck perpendicular to its protrusion beyond the outside face of the cask.

Trunnions appear to project around 1 11/32” beyond the face of the cask. Staff is concerned that a direct strike by the penetrating bar may damage the trunnion such that it may get loose and potentially fall out of the cask, adversely affecting dose rates readings in the area.

This information is needed by the staff to determine compliance with the requirements of 10 CFR 71.73(c)(3).

Holtec’s Response to Observation 2-7:

Table 5.4.4 presents the dose rates calculated for a hypothetical accident condition with 4 trunnions missing.

The maximum dose rate 1 meter from the missing trunnions was 0.24 mSv/hr which is well below the 10 CFR 71.51 accident limit of 10 mSv/hr.

NRC Observation 2-8:

Describe the performance of the package for the HAC puncture scenario when a previously damaged corner of the cask, as a result of the 9 m drop, is struck once more by the bar described in the puncture scenario.

Large plastic deformations were observed in the cask corner as a result of the 9 m drop (corner drop configuration) test as reported in Figure 2.7.5 on page 2-64. It is unclear with respect to cumulative damage, how the same region of the cask will perform during the puncture test if the cask is dropped in a corner drop configuration onto the bar specified.

Note that the cask could strike the puncture bar at a slightly rotated orientation. That is, the cask does not necessarily have to strike the puncture bar flush.

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

Holtec's Response to Observation 2-8:

The updated analysis of the HI-STAR ATB 1T package 40-inches puncture drop (HAC event) accumulate the deformations resulting from the 30-ft CGOC drop event as initial condition. The deformation and or the damage resulting from the CGOC is accumulated when performing the package corner puncture drop onto the 6 in. diameter bar.

NRC Observation 2-9:

Describe the performance of the package for the HAC puncture scenario when the trunnion area is struck directly by the bar described in the puncture test.

Trunnions (item 19) have been described as being able to sustain a direct impact observed in the puncture scenario by retracting back into a cavity. However, it is unclear how the trunnion hollow shaft (item 20) surrounding the trunnion will behave when it becomes the recipient of all the forces generated by the puncture bar once the trunnion (item 19) retracts.

Note that the upper long containment plate wall plate (item 4) backing the trunnion hollow shaft (item 20) is thinner in this region due to the presence of the trunnion assembly itself.

This information is needed by the staff to determine compliance with 10 CFR 71.73(c)(3).

Holtec's Response to Observation 2-9:

In order to address the concerns raised by the NRC staff, an additional simulation is considered wherein the package is dropped onto the puncture bar such that the puncture bar directly impacts the inner containment shell of the package. To maximize the damage to the containment shell, it is assumed that both the trunnion and its sleeve (trunnion hollow shaft surrounding the trunnion) are eliminated. Presence of either of the abovementioned components viz. the loose trunnion or the hollow shaft surrounding the trunnion will result in dissipating some of the impact energy thereby alleviating the deformation in the containment shell.

NRC Observation 2-10:

Describe the amount of torque used for the bolts that secure the BFA tank lid.

Page 7-4 states that bolts that are part of the BFA tank will be installed and torqued by the supplier. It is unclear what torque will be used to minimize vibrational effects in the bolt assemblies.

This information is needed by the staff to determine compliance with 10 CFR 71.71(c)(5).

Holtec's Response to Observation 2-10:

As described in Chapter 1 of the SAR (p. 1-9), the metallic seals installed at the BFA tank lid interface only serve a "cleanliness" function. Therefore, the BFA tank is not credited in the SAR as a containment barrier, and there is no minimum pre-load (or torque) requirement for the BFA tank lid bolts. Accordingly, the text on page 7-4 of the SAR has been revised as follows:

"7. The BFA-Tank lid bolts are installed and torqued to wrench tight."

<u>NRC Observation 2-11</u>:

Justify how the closure lid locking system (CLLS) will remain functional during NCT and will prevent the lid of the package from coming loose during drop and penetration tests described under HAC.

No physical drop testing data has been presented related to the CLLS and its interaction with the package for drop tests specified under NCT and HAC. It is unclear how the CLLS will perform when the package is dropped since analytical models of the CLLS using LS-DYNA are not linked to physical drop test data.

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 71.73.

<u>Holtec's Response to Observation 2-11</u>:

As part of the HI-STAR ATB 1T benchmark program, three physical drop tests are performed on the HI-STAR ATB 1T ¼-scale package (true replica of the full HI-STAR ATB 1T package design) which are subsequently benchmarked by the state-of-art numerical analytical code LS-DYNA. The drop tests indicated that the package top flange above the closure lid surface sustained some plastic deformations. In particular, the top flange top surfaces along the longer package edges bent away in the cask transverse (lateral) direction indicating that the flange cross-sectional area above the CLLS wedges was weak in the ¼ scale test unit. Since the CLLS wedge remained structurally integral and the package sealing surfaces essentially remained flat, there was no threat to the containment integrity to the transport package due to the limited lateral deformation noticed in the top flange. Nonetheless, remedial measures were implemented in the full cask design to limit the lateral deformations in the top flange, as depicted in the revised HI-STAR ATB 1T cask drawing listed in section 1.3 of the revised SAR.

NRC Observation 2-12:

Justify the classification of the cylinder systems as not important to safety with respect to the closure lid locking system.

The package's ability to maintain the closure lid in place is based on the CLLS ability to function properly via a cylinder system. If the cylinder system were to fail during normal and hypothetical accident conditions, the CLLS could potential fail in its ability to retain the closure lid. This system and its components should be shown in the licensing drawings and its ability to withstand normal and accident conditions should be proven.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.71, and 71.73.

Holtec's Response to Observation 2-12:

As stated in Section 1.2.4 of the SAR:

If employed, hydraulic or pneumatic cylinder systems act as drivers for engagement and disengagement of the CLLS with the cask. Materials for the cylinder systems are selected according to suitability for the application and the work environment. The cylinders systems are NITS and their design is outside the scope of this SAR. Instead, the design criteria applicable to the cylinder systems are set down in the following to ensure that the essential performance characteristics of the package are maintained:

1. Cylinder systems are designed to withstand routine and normal transport conditions and mishaps.
2. Cylinder systems include pressure relief devices.
3. Fluid in the cylinder systems are non-flammable.
4. Once engaged with the cask, the CLLS engagement is not compromised by malfunction or failure of the cylinder system (a fail-safe design).

The cylinder system is not important to safety, as its function is only operational, to engage or disengage the locking wedges. During shipment, the cask wedges are locked in place with the Locking Wedge Locking Pin, which is an ITS component independent of the cylinder system. Therefore, failure or malfunction of the cylinders does not affect the engagement of the locking wedges.

NRC RSI 3-1:

Provide documentation, e.g., vendor datasheets, confirming the performance of the CLLS fluid and lubricants.

Information necessary to perform a detailed technical review includes the following:

a) Provide the allowable temperature range of the CLLS, including the hydraulic fluid, and explain the behavior of the CLLS hydraulic fluid when exposed to low and high temperatures during NCT and HAC.
b) Provide the maximum temperature of the CLLS system, including lubricant and hydraulic fluid, during NCT and HAC.
c) Confirm that the hydraulic fluid has sufficient expansion volume to accommodate reduced density at high temperatures.
d) Provide documentation that supports Section 2.2.7 statements that the lubricant and fluid are non-flammable and have sufficient radiation resistance.

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

Holtec's Response to RSI 3-1:

As NITS components used only for operation of the wedge locking system (see response to 2-12), the operating performance of the hydraulic system fluids and lubricants is not relevant to the cask licensing basis. Details of the hydraulic system will be specified in the fabrication drawings (non-licensing manufacturing documentation). Selected fluids and lubricants will be shown to meet the requirements of Subsection 2.2.7 of the SAR and to be suitable for the operating environment.

NRC RSI 3-2:

Provide vacuum drying thermal models or clarify that the NCT and HAC thermal models are bounding.

Temperatures within a package often rise during the vacuum drying process. Section 3.3.11 indicates that vacuum drying would be performed, but no thermal analysis was provided nor was there discussion stating that the supplied analyses were bounding.

This information is needed by the staff to determine compliance with 10 CFR 71.33 and 71.71.

Holtec's Response to RSI 3-2:

There is no need to perform the thermal evaluation of the vacuum drying operation. For the HI-STAR ATB 1T cask, there is no spent nuclear fuel and thus there is no concern of the peak cladding temperature limit. The two safety concerns due to the temperature rise are the temperature of the cask closure lid seals and the cask cavity pressure. The thermal evaluation of the normal transport condition is performed to ensure the cask closure lid seal temperature and the cavity pressure meets their limits. During the vacuum drying operation, the cask closure lid is not installed and thus there is no concern of the closure lid seal temperature. The vacuum drying pressure is low and thus it will not influence the structural integrity of the HI-STAR ATB 1T package. The waste contents and the cask components are made of stainless steel and carbon steel. The temperature of the waste contents and the cask components during the vacuum drying operation will not challenge the structural integrity of the steel components. Therefore, there is no safety concern due to the temperature rise during the vacuum drying operation. This justification will be added to Section 3.3.11 of the HI-STAR ATB 1T SAR.

The temperature during the vacuum drying operation is expected to be similar to that during the normal transport condition. The thermal model of the normal transport condition does not credit the heat convection by the air movement inside the cask. Through the cavity empty space, the heat is dissipated by heat radiation and heat conduction of air. The thermal conductivity of the low pressure vapor at 8 millibar has the same order of magnitude of the thermal conductivity of the air. Thus, the heat dissipation through the empty space inside the cask will not be significantly affected if the cavity is filled with the low pressure vapor instead of the air. On the other hand, the vacuum drying operation is performed inside the building and thus there is no insolation on the cask. The BFA-Tank lid and the cask closure lid are not installed. Instead, a radiation shielded drying cover is placed on the cask. The influence of the insolation and the cask closure lid is larger than the influence of the thermal conductivity difference. Therefore, the temperature during the vacuum drying operation will not be significantly higher than that of the normal transport condition and will be bounded by that of the fire accident condition.

NRC RSI 3-3:

Confirm that the methodology of not modeling the content during HAC results in a bounding thermal analysis.

According to Section 3.4.3.2 of the application, the HAC thermal models do not explicitly model the package cavity and content. Provide an analysis explaining why applying a constant temperature to the content is bounding, rather than modeling the thermal mass associated with the content/container during the HAC and post-fire cooldown.

This information is needed by the staff to determine compliance with 10 CFR 71.73.

Holtec's Response to RSI 3-3:

The thermal model of HAC (i.e. fire accident) includes the cask contents. The contents inside the cask are modeled as a solid box assuming uniform heat generation and effective thermal properties. The effective density and specific heat of the solid volume are calculated as the volume weighted average properties of all the contents inside the cask cavity. The calculation is documented in Holtec Report HI-2156585 by the excel file "fire-cask-cavity-eff-properties.xlsx". By matching the maximum temperature to that in the licensing basis model under the normal condition, the effective thermal conductivity of the contents inside the cask cavity is found to be 0.242W/m-K (see Holtec Report HI-2156585). This simplified thermal model is evaluated under normal transport condition and is adopted as the initial condition for the fire evaluation. The contents inside the cask cavity are also modeled as the solid box during the fire and post-fire cooldown. In Section 3.4.3.2 of the HI-STAR ATB 1T SAR, the description "the cask cavity is not explicitly modeled in the fire evaluation" will be revised to "the cask cavity is modeled as a solid volume with effective thermal properties".

The simplified thermal model is adopted for the fire evaluation because the position of the BFA-Tank inside the cask may change after the drop and puncture accident. The fire accident is assumed to occur immediately after the drop and puncture accidents. The temperature of the cask will not change significantly during the drop and puncture accidents. Thus, the cask component temperature at the beginning of the fire (i.e. the initial condition) should be essentially same as that under normal transport condition. Under normal transport condition, the BFA-Tank sits on the containment base plate of the cask. After the drop and puncture accidents, the BFA-Tank may sit on any internal surface of the cask, e.g. the containment base plate, the containment wall plates or the closure lid of the cask. Similarly, the position of the BFA-Tank Cassette (BTC) inside the BFA-Tank may change after the drop and puncture accidents. Consequently, the empty space occupied by air inside the cask and the BFA-Tank changes. It is not possible to exactly obtain the initial temperature field of the air volume inside the cask and the BFA-Tank for the fire evaluation. Thus, for the fire evaluation, the contents inside the cask are simplified to be a solid box. The simulation of the fire accident shows that the total heat absorbed by the cask is more than 100 times the decay heat released from the waste when the seal temperature reaches its maximum. Therefore, the impact of the simplified cask cavity on the cask component temperature is insignificant as compared to the fire.

For the HI-STAR ATB 1T cask, there is no spent fuel and thus there is no concern of the peak cladding temperature limit for the fire accident. The only safety concern is to ensure the containment boundary is intact. The fire simulation was performed for a sufficient duration to allow the cask containment boundary components and the closure lid seals to reach their maximum temperatures. The temperatures of the cask containment boundary components are below their respective safety limits.

The simulation shows that the maximum temperature inside the cask is essentially unaffected by the fire when the cask containment boundary components and the closure lid seals reach their maximum temperatures. As the heat from the fire gradually propagates into the cask cavity, the temperature of the waste contents will rise. However, it will take a long time for the waste contents to reach the maximum temperature and it is not necessary to obtain the exact value of the maximum temperature. The maximum temperature of the cask cavity will not exceed the fire temperature and thus will be well below the melting temperature of carbon steel and stainless steel. Therefore, there is no safety concern from the temperature rise of the waste contents and BFA-Tank if the cask containment boundary is intact. This explanation will be added to Section 3.4.3.1 of the HI-STAR ATB 1T SAR.

NRC Observation 3-4:

Provide further details on the proposed content, especially as it relates to pyrophoric and radiolysis-related considerations, which could impact the operation of the package.

Section 1.2.2 of the application indicates that content is non-fuel waste, which can include debris/chips. It is not certain if the varied non-fuel waste could include small metal filings/powder that could be pyrophoric or could include materials that undergo radiolysis, such as plastics.

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

Holtec's Response to Observation 3-4:

The radioactive waste contents transported in HI-STAR ATB 1T are from segmented reactor internals typically made of stainless steel. Metallic debris and chips may form during segmentation of the stainless steel components. Waste in the form of chips and metallic debris, stored in "chip drums" or "debris containers" with approximate total weight of up to 700 kg are loaded into some BFA tanks. No appreciable quantity of chips is expected to be less than 200 micrometers. If average particle diameter particle size exceeds 100 micrometers the pyrophoric hazard of metal powders is greatly reduced or eliminated [3-4]. In addition, Reference [3-4] shows that stainless steel powders do not ignite i.e. stainless steel metal filings are not pyrophoric.

Explosives, corrosives, and pyrophorics are not transported in HI-STAR ATB 1T. Fissile radionuclides that maybe pyrophoric, such as uranium and plutonium [3-4], are present only in residual amounts, less than 2 grams per container as shown in Table 7.1.2 of HI-STAR ATB 1T SAR.

Organic materials that can undergo radiolysis (ex. plastics, water), are not included in any appreciable quantity in the radioactive waste contents transported in HI-STAR ATB 1T. The BFA-Tank is vacuum dried to remove all bulk water from the cask and contents. Only moisture naturally occurring in air (~17.3 g of water per m^3 of air at 68F) remains in the cask cavity thus preventing appreciable gas generation from radiolysis of water. Vacuum drying parameters are provided in Table 7.1.1 of HI-STAR ATB 1T SAR.

[3-4] Explosibility of Metal Powders, Murray Jacobson et. al., Report of Investigation 6516, 1964, Bureau of Mines.

NRC Observation 3-5:

Explain how the content will be accurately determined to ensure that the content's decay heat will be limited to 1.75 kW and its activity limited to the quantity described in Table 7.1.2.

There is no description in Chapter 7 that explains how the content's decay heat and activity would be confirmed prior to shipment. In addition, the activity listed in Table 7.1.2 should be clarified (i.e., 9010 times a Type A quantity).

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

Holtec's Response to Observation 3-5:

The following Notes 2 and 3 have been added below Table 7.1.2, "

> 2. The user shall verify prior to loading the ATB 1T cask that the specific activity of the waste components to be loaded have been pre-calculated (i.e. calculated prior to loading the ATB 1T cask) using a widely-recognized radiation-safety source-term computer code(s) that is accompanied by design control measures for ensuring the quality of computer programs. The "pre-calculation" is required to ensure the package decay heat and the package waste activity comply with the maximum values specified in this Table.
> 3. Does rate surveys shall be performed prior to shipment as specified in this Chapter to verify an acceptable loading of the HI-STAR ATB-1T cask in addition to demonstrating compliance with 10CFR71.47 [7.1.3]."

"9010 times a Type A quantity" is equivalent to 3.60E+15 Bq, which is the "Maximum permissible Co-60 specific activity of fully loaded BFA-Tank T-200" in Table 7.1.2 where Co-60 A_1 and A_2 values are 1.1×10^1 Ci. Since this last row is a duplication of a value already displayed in Table 7.1.2, this last row referring to "a Type A quantity" is removed for clarity.

Table 1.2.1 presents the maximum calculated decay heat for a given Waste Package given the maximum permissible activity of a fully loaded BFA-Tank in Table 7.1.2 and using a Cobalt-60 watts per curie conversion of 1.54E-02 [1]. An additional 10% is conservatively added to the decay heat calculation to account for radionuclides other than Co-60. All calculated decay heat values in Table 1.2.1 are below the 1.75 kW limit in Table 7.1.2.

[1] Integrated Data Base Report -1996: U. S. Spent Nuclear Fuel and Radioactive Waste, Inventories, Projections, and Characteristics," Appendix B, Characteristics of Important Radionuclides, DOE/RW-0006, Rev. 13, December 1997.

NRC Observation 3-6:

Explain the effect of thermal stresses on the behavior of the CLLS wedge closure.

The effectiveness of the containment boundary is dependent on the package lid, which is closed using the CLLS wedge design. However, an explanation of the CLLS performance during HAC, especially due to thermal stresses, was not provided.

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

Holtec's Response to RSI 3-6:

During NCT, thermal stresses have no effect on the behavior of the CLLS. This is due to the low design basis heat load of the cask (see Table 7.1.2 of the SAR) and the fact that the maximum metal temperatures of the top flange and the closure lid (as well as the locking wedges) are nearly equal under NCT (see Table 3.1.1 of the SAR). Moreover, the locking wedge material (SB-637 N07718) has a slightly lower coefficient of thermal expansion than the top flange and closure lid material (Type 304 SS), so the thermal loading under NCT will not result in any increased stress on the CLLS due to differential thermal growth.

The more significant risk to the CLLS and the effectiveness of the containment boundary is associated with the fire event during HAC. The worst case scenario is a top-down drop with the cask coming to rest on the closure lid followed by a 30-minute enveloping fire per 10CFR71 requirements. Since the top flange is directly exposed to the flame, it heats up more than the closure lid locking wedges and causes differential thermal growth between these two components. The risk is that, with the cask oriented upside down, the differential thermal growth would allow the lid to displace downward and unload the sealed joint between the closure lid and the compression land on the top flange.

To evaluate this risk, the maximum differential thermal growth between the top flange and the closure lid locking wedges has been calculated for the fire event and compared with the minimum useful springback of the seals specified in Table 2.2.2. Since the calculated differential thermal growth is much less than the useful springback, the seals will remain functional and the containment boundary will not be compromised. The differential thermal growth calculation is documented in calculation package [2.6.4].

In summary, thermal stresses are not an issue for the CLLS wedge closure during NCT or HAC. The most significant risk to the CLLS performance is a potential unloading of the seals due to differential thermal growth during a hypothetical fire accident. However, calculations have been performed, which show that the maximum differential thermal growth is less than the useful springback of the seals. Therefore, the performance of the CLLS is not adversely affected by the thermal loads acting on the cask during NCT or HAC.

Editorial:

Correct page 2-55 of the application, or clarify whether the stress analyses assume a 30 minute or 15 minute HAC fire.

Holtec's Response to Editorial:

Corrected. 30-minutes HAC fire.

NRC RSI 4-1:

Provide documentation, e.g., vendor datasheets, supporting the effective performance of the FFKM seals, which are part of the containment boundary, during NCT and HAC.

Documentation provided should address the following:

a) allowable temperature range,
b) short term maximum temperature time period allowed by manufacturer,
c) resistance to radiation,
d) thermal expansion coefficient and the impact of temperature change on seal effectiveness, and
e) resistance to helium permeation, which affects leakage testing of the seal material.

This information is needed by the staff to determine compliance with 10 CFR 71.33 and 71.51.

Holtec's Response to RSI 4-1:

The o-ring material is FKM fluorocarbon. This has been corrected in the SAR. Additional information as specified above has been provided in Table 2.2.2 in Chapter 2.

<u>NRC RSI 4-2</u>:

Provide details of the O-ring gland dimensions from the seal manufacturer in the licensing drawings.

The FFKM O-rings are an important component of the containment boundary and, according to Section 2.2.4 of the application, seal performance is dependent on proper sizing between the O-ring and the gland dimensions. However, gland and O-ring details were not provided either in the drawings or the application.

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

<u>Holtec's Response to RSI 4-2</u>:

Dimensional details of the o-ring groove dimensions are added to licensing drawing (9786 Rev. 3).

NRC Observation 4-3:

Specify the qualifications of the individuals performing the leak test and writing the leak test procedures.

Chapter 8 of the application did not specify the qualifications of those involved in writing and performing helium leak testing. The "American Society for Nondestructive Testing Standard for Qualification and Certification of Nondestructive Testing Personnel (ANSI/ASNT CP-189-2006)" and the "Recommended Practice No. SNT-TC-1A" provides the minimum training, education, and experience requirements for NDT personnel who perform leak testing and write leak test procedures.

This information is needed by the staff to determine compliance with 10 CFR 71.37(b) and 71.87.

Holtec's Response to Observation 4-3:

We agree with the staff's position on the need for clarification. The following proposed changes have been incorporated in SAR (provided with this RAI response) for clarification:

Subparagraph 8.1.4 regarding acceptance leak testing: First paragraph is changed to "Leakage rate tests on the cask containment system shall be performed per procedures written and approved in accordance with Chapter 7 of this SAR and the requirements of ANSI N14.5, 1997 [1.2.4]. All testing shall be performed in accordance with written and approved procedures written by qualified personnel in accordance with Holtec QA program. The written and approved test procedures shall clearly define the test equipment arrangement. The applicable recommended guidelines of SNT-TC-1A [8.1.2] shall be considered as minimum requirements.

Subparagraph 8.2.3 regarding maintenance leak testing: Third paragraph is added stating "Leakage rate tests on the cask containment system shall be performed per procedures written and approved in accordance with Chapter 7 of this SAR and the requirements of ANSI N14.5, 1997 [1.2.4]. All testing shall be performed in accordance with written and approved procedures written by qualified personnel in accordance with Holtec QA program. The written and approved test procedures shall clearly define the test equipment arrangement. The applicable recommended guidelines of SNT-TC-1A [8.1.2] shall be considered as minimum requirements.

NRC Observation 4-4:

Specify the quality assurance category of the FFKM seal.

Section 2.2.4 of the application indicates that the FFKM seal is Important to safety. However, there was no indication that the seals are associated with the more rigorous quality assurance category commensurate with its function.

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

Holtec's Response to Observation 4-4:

The o-ring material is FKM fluorocarbon. This is corrected in the SAR Table 2.2.2. The seal is a cask containment boundary component, as indicated in the cask licensing drawing (9786 Rev. 3). Containment components are ITS Category A, which is the most rigorous quality assurance category. Evaluation of packaging components ITS category is performed in fabrication documentation (non-licensing).