June 12, 2008

Ms. Tammy Morin, Licensing Manager
Holtec International
Holtec Center
555 Lincoln Drive West
Marlton, NJ 08053

SUBJECT: LIST OF OPEN TECHNICAL ISSUES RESULTING FROM THE REVIEW OF THE HOLTEC INTERNATIONAL HI-STAR 180 PACKAGE APPLICATION (TAC NO. L24076)

Dear Ms. Morin:

Holtec International's (Holtec's) original application requesting U.S. Nuclear Regulatory Commission (NRC) approval of Holtec's HI-STAR 180 Package design by issuance of Certificate of Compliance (CoC) No. 9325 was submitted by letter dated January 10, 2007. Subsequently, Holtec withdraw that application on March 9, 2007. By letter dated August 17, 2007, Holtec re-submitted its HI-STAR 180 application, in accordance with the provisions of 10 CFR Part 71.

The NRC staff has suspended its review of your application because of significant issues identified with the Metamic HT structural material data and structural modeling issues with LS-DYNA. The staff has enclosed a list of open items in all technical areas that it has identified to date. However, this list should not be considered all inclusive because there may be a need for additional information based on Holtec's response. Further, the staff believes that there are significant technical analyses and materials data that need to be provided before this review could be resumed (See questions in Section 2.0 of the Enclosed).

Please note that the questions regarding Metamic HT should be viewed in the context that results from some tests will determine to a large extent the necessity or adequacy of other testing. Therefore, Holtec needs to evaluate the various test results and determine subsequent test requirements. The purpose of the material testing is to adequately determine the behavior and properties of Metamic HT versus the requirements of its specific intended application. It is assumed that testing will employ samples of Metamic HT that are identical to the final form of the material that is used in a spent fuel basket, specifically, rolled plate

Therefore, we request a meeting with Holtec to discuss the staff's questions related to Metamic HT materials properties and structural analyses modeling. Also, the staff wants to understand Holtec's plans to address these deficiencies.

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Please reference Docket No. 71-9325 and TAC No. L24076 in future correspondence related to this licensing action. If you have any comments or questions, please contact me at (301) 492-3317.

Sincerely,

/RA/
Stewart W. Brown, Senior Project Manager
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9325
TAC No. L24076

Enclosure: Request for Additional Information

Please reference Docket No. 71-9325 and TAC No. L24076 in future correspondence related to this licensing action. If you have any comments or questions, please contact me at (301) 492-3317.

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HOLTEC INTERNATIONAL

DOCKET NO. 71-9325

OPEN TECHNICAL ITEMS

RELATED TO THE HI-STAR 180 PACKAGE

This list of open items identifies additional information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its safety review of the HI-STAR 180 package application. The requested information is listed by chapter number and title in the applicant's Safety Analysis Report (SAR). NUREG -1609, "Standard Review Plan for Transportation Packages for Radioactive Material," was used by the staff in its review of the application.

Each individual item describes information needed by the staff to resume its review of Metamic HT and structural analyses, and to complete its review of the application in other technical areas.

1.0 GENERAL INFORMATION

1-1 Provide both the maximum expected length of time spent fuel will be stored in a HI-STAR 180 package after loading is complete before actual shipment of the spent fuel and the maximum expected length of time the spent fuel will be stored in the HI-STAR 180 package at the destination site before the spent fuel is removed from the packaging. Also, provide justification for these on-site, in transportation packaging storage times.

The stated purpose of 10 CFR Part 71 is to establish the "[r]equirements for packaging, preparation for shipment, and transportation of licensed materials…" Whereas the stated purpose of 10 CFR Part 72 is to "establish requirements, procedures, and criteria for the issuance of licenses to receive, transfer, and possess power reactor spent fuel … with spent fuel storage in an independent spent fuel storage installation (ISFSI) and the terms and conditions under which the Commission will issue these licenses." Based on Holtec's statements in the SAR, one could construe NRC's approval of the HI-STAR 180 package design under the provision of 10 CFR Part 71 could result in on-site storage of spent fuel in the HI-STAR 180 for a number of years without NRC review or approval of this design under the provisions of 10 CFR Part 72.

This information is required by the staff to assess compliance with the requirements of 10 CFR Part 71.

1-2 Revise the engineering drawings to include the dimensions of seals and seal grooves, as well as surface finish specifications.

Technical content of engineering drawings need to include the dimensions of seals and seal grooves, as well as surface finish specifications.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33.

1-3 Provide a schematic diagram to illustrate the canopy type personnel barrier and perform a thermal evaluation for the transportation package with canopy type personnel barrier installed.

On page 1.2-3, of the SAR, a canopy type personnel barrier is described briefly. Based on the description, the barrier could influence the heat transfer from cask to the environment. Provide the thermal analysis for the package configuration with the canopy personnel barrier installed.

This information is required by the staff to assess compliance with 10 CFR 71.35.

1-4 Provide a description in the SAR of the methodology used to obtain the maximum heat load per fuel assembly in Table 1.2.8 to 1.2.10. This discussion should: (1) clarify whether the combination of burnup, enrichment, cooling time, determine the required maximum heat load per fuel assembly; (2) explain different cooling time could result in same heat load per assembly with same enrichment and burnup, *i.e.*, Region 4 and 7 in Table 1.2.8 and Region 1 and 6 in pattern C of Table 1.2.9; (3) explain different burnup could result in same heat load per assembly with same enrichment and cooling time, *i.e.*, Region 2 and 5 in pattern C of Table 1.2.9; and (4) clarify the statement on page 1.2-13, of the SAR, regarding the package loading pattern, "to help ensure the specified limits are not exceeded, all loading patterns shall be reviewed and approved by Holtec." This question is related to question 5-3.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33

2.0 STRUCTURAL EVALUATION

2-1 Demonstrate that three to five usable accelerometers employed in the HISTAR-100 quarter scale test is sufficient instrumentation for benchmarking a computational simulation using LS-DYNA.

The LLNL report "Guidelines for Conducting Impact Tests on Shipping Packages for Radioactive Material" (1995) states "In a benchmark test program, instrumented time history measurement of the acceleration, stress/strain, or displacement of the impact response of the safety related components of the package should be taken and compared with analysis results." The staff agrees that the available acceleration data as well as the qualitative observations of the quarter scale test were sufficient to inform the licensing basis for the HI-STAR 100. However, the staff does not agree that this limited data set is sufficient for benchmarking the computational capability of LS-DYNA with respect to structural behavior except for rigid body deceleration of the package outer surfaces or impact limiter crushing characteristics.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-2 Justify the selective use of nodal acceleration data when comparing LS-DYNA output to test data as well as the differences noted between methods for obtaining a deceleration time history.

In the Stage III Benchmarking Report acceleration data is reported for nodes 145, 241, and 1722. This information is derived from velocity data that has been differentiated. Two other nodal locations identified for the end drop, namely nodes 325 and 1341, are not included in the analysis. When these nodes are subjected to the same process, differentiation followed by acceleration time history filtering at 450 hertz (Hz), similar deceleration time history curves are produced. However, looking closely at node 1341, when direct nodal acceleration is plotted then filtered at 450 Hz, the peak acceleration is 246 g's rather than 230 g's using differentiated velocities. Furthermore, when node 325 is represented by filtered nodal acceleration directly, the peak deceleration is 484 g's rather than 226 g's for differentiated velocity, and node 1722 has a peak deceleration of 362 g's versus 227 g's.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-3 Justify the use of tetrahedral elements for the aluminum honeycomb impact limiter material.

Tetrahedral elements are known to be less accurate than hexahedral elements on a per element basis. A confirmatory crush analysis was undertaken by staff to determine the relative differences between tetrahedral and hexahedral elements and the results showed significant difference in the amount of material deformation (energy absorption) as well as impact forces imparted on the impact surface. The staff requests a justification for the use of tetrahedrons to model the aluminum honeycomb in the impact limiter.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-4 Justify the selective use of material properties for the aluminum honeycomb impact material.

Holtec reports test data from the manufacturer as the basis for developing the honeycomb material model, however, Holtec does not appear to use all available material properties in a meaningful way. For example, the publicly available product guide for Hexcell, lists additional material properties such as shear strength, that are not incorporated into the material model for the aluminum honeycomb.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-5 Justify the use of isotropic material properties for the aluminum honeycomb.

The material model options used for LS-DYNA Mat-26 are chosen such that the material has equal strength in the three orthogonal normal directions as well as having the three shear strength values equal to the values of normal compressive strength. The Stage III Benchmarking Report states as an assumption “4.2 The impact limiter honeycomb material is assumed to resist only compression in a drop event. This is a reasonable assumption consistent with the expected function and orientation of the impact limiter honeycomb blocks.” Given that the material used is classified as unidirectional or bidirectional (cross core), provide justification for using an isotropic material model to represent a material that is not isotropic.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-6 Demonstrate that the aluminum honeycomb material is not subject to substantial mesh sensitivity with respect to element size and aspect ratio.

Holtec did not indicate whether any mesh sensitivity was investigated for the given material type. Staff requests that Holtec perform a mesh sensitivity study to demonstrate that the material model is well conditioned regardless of the analyst’s choice of mesh size.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-7 Demonstrate that the use of globally oriented material axes is appropriate for the LS-DYNA benchmark analysis.

The analyses presented assume a global orientation of the material axes which means that the three orthogonal normal crush directions are oriented along the global X, Y, and Z axes respectively. For example, as the impact limiter rotates from an end drop orientation to a C.G. over corner orientation, the uniaxial material properties in the axial direction would remain oriented in this initial global direction despite material axes (and thus the material properties such as crush strength) physically rotating. There is no evidence presented that LS-DYNA is capable of handling this type of material orientation change by using global material axes. Staff requests a demonstration that the results for a properly constructed honeycomb material model are not affected by the choice of global material axes

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-8 Justify the use of manufacturer supplied material properties given that the aluminum honeycomb material is altered by pre-crushing prior to installation.

Holtec indicated that a pre-crush of the aluminum honeycomb is utilized to remove an initial spike in the crush strength exhibited by the raw honeycomb material. The staff has concerns that this alteration may induce changes in the structural response under dynamic load and requests that the applicant provide justification for the use manufacturer’s specifications given that the material no longer maintains the stock configuration.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-9 Demonstrate that the methodology used for the impact limiter material is robust enough to simulate the behavior of the likely range of honeycomb materials to be used.

Because a complex failure mechanism for the aluminum honeycomb is being homogenized in the computational modeling effort, the staff requests a demonstration that the chosen material model is capable of simulating the structural behavior of only the aluminum honeycomb under manufacturer test conditions. Given that the manufacturer's specifications and assembly procedures may change over time, thereby changing the material response, it is incumbent upon Holtec to provide a reasonably robust material model for the aluminum honeycomb.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-10 Provide a more thorough explanation of the methodology used to connect the impact limiters to the overpack model.

The benchmark report states that "the overpack region where top impact limiter attachment bolts are modeled by relatively small elements, is connected to the rest of the overpack model through the CONTACT_TIED_SURFACE_TO_SURFACE command." The staff requests a more explicit explanation of the connection in this region as it is not clear what is achieved by this modeling operation. For example, does it mean that the bolt surfaces are connected to the overpack mating surfaces with this operation?

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-11 Demonstrate that the mesh used to model the impact limiter attachment bolts is not subject to mesh sensitivity in the Stage III report.

Inspection of the bolt shank mesh in the Stage III model shows an abrupt mesh transition at the plane where the bolt enters the bolt hole. The bolt mesh just to the interior of the hole is relatively coarse compared to the mesh just outside of the hole. This type of mesh arrangement has a tendency to produce an unrealistic hard spot along this critical shear plane and may skew the results such that premature failure is indicated.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-12 Demonstrate that the use of ASME code reduction of area values, or "q" values, are consistent with manufacturer material certifications with respect to bolt failure strains.

The use of an ASME "q" value for calculating failure strain is inappropriate for a benchmark analysis. The tabulated "q" values are design minimums which yield conservative results for design, however, they are not representative of the true failure state of the actual bolt material used in the test. Material data supplied by the bolt manufacturer or another form of test data should be used for "q" values.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-13 Either provide: (1) justification for the statement "The ability of LS-DYNA to simulate the performance of the fasteners in the scale model tests, as demonstrated by the Stage III scale model test benchmarking, provides to the designer, for the first time in the annals of transport package design, the ability to peer into the response of the bolted joints and predict their sealworthiness with confidence" or (2) the results of benchmarking the bolt model against test results that can be found in the open literature.

Without a valid, benchmarked bolt model, no comparison or subsequent conclusion can be drawn from simply observing modeling results of a complex bolted connection. Thus, it is not possible to validate the impact limiter bolt behavior without a bolt model benchmarked against test data related to this type of bolted connection. Furthermore, the benchmark report states that "The LS-DYNA solution can be reasonably relied upon to provide key post-impact information such as: The state of stress/strain in every bolt in the joint, the amount of the contact pressure on the "land" in the controlled compression joint, and the extent of decompression of the gasket(s)." This information alone is not sufficient to demonstrate that this is the response of the physical package without test data to substantiate such claims. Currently, no such test data exists in docketed materials provided to the NRC. Therefore, the bolt model should be benchmarked against test results that can be found in the open literature (See References listed below). Such a benchmark should be similar in scope to the work performed by the Sandia National Laboratory in support of the staff during the Private Fuel Storage hearings.

References:

J.J. Wallaert and J.W. Fisher, "Shear Strength of High-Strength Bolts," *Journal of the Structural Division*, ASCE Vol. 91, ST3, June 1965.

E. Chesson, Jr., N.L. Faustino, and W.H. Munse, "High-Strength Bolts Subjected to Tension and Shear," *Journal of the Structural Division*, ASCE, Vol. 91, ST5, October 1965.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-14 Demonstrate how an un-validated bolt model in LS-DYNA assures greater confidence and assurance than a physical test with respect to seal integrity.

Holtec states that "The LS-DYNA based assertion of moderator exclusion, therefore, should be viewed with greater confidence and surety than one based on physical testing." While it can be argued that information regarding water in-leakage during test conditions is difficult to obtain, the computational model provided by Holtec has no reliability in its current form given that the containment boundary, including the primary and secondary lid bolts, has not been benchmarked.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-15 Provide a description of the manufacturing control processes and inspections that will be in place for the Metamic material.

In Section 1.2.1.6 of the SAR Holtec states "material and manufacturing control processes must be established…inspections steps must be implemented…". Further, Metamic is classified as important to safety. Thus, the control processes and inspections should have been developed and in place as a requirement for the use of this material which is being evaluated for its safety function.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-16 Provide justification for changing the aluminum honeycomb meshing methodology between the Stage III Benchmarking Report and the analysis provided for the HISTAR-180.

Holtec used a tetrahedral mesh for a portion of the honeycomb material in the impact limiter in the Stage III Benchmarking Report while the analysis for the HISTAR-180 uses all hexahedral elements. There is no explanation for this change in methodology.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-17 Provide justification for changing the methodology used for the impact limiter attachment bolt mesh discretization between the Stage III Benchmarking Report and the HISTAR-180 numerical models.

Holtec utilized a bias mesh when modeling the impact limiter attachment bolts in the Stage III Benchmarking Report. The bias is characterized by the mesh dimension parallel to the long axis of the bolt becoming progressively smaller as the mesh nears the critical shear plane and then just beyond the shear plane the mesh becomes very coarse. The mesh for the impact limiter attachment bolts for the HISTAR-180 model has a very different mesh thereby introducing a potential change in behavior between the bolts from the benchmarking effort and the bolts from the HISTAR-180.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-18 Provide a discussion explaining the severe deformation observed in a fuel basket plate during the side drop simulations for both the F-32 and F-37 configurations.

A fuel basket plate adjacent to the base plate in both the F-32 and F-37 side drop evaluations exhibits a severe local deformation (approximately 1 in.) that is not credible given the uniform loading on the plate.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-19 Provide a discussion explaining why the large plastic strains observed in the fuel basket adjacent to the primary lid/baseplate during an end drop are ignored given that they exceed the reported failure strain of Metamic.

Careful observation of the plot showing equivalent plastic strain shows that the maximum plastic strain in the basket exceeded the plastic strain in the active fuel region as reported by Holtec. Since these plastic strains exceeded the failure strain of Metamic, the staff needs to understand why Holtec does not consider these large plastic strains relevant.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-20 Provide a discussion explaining why consideration of gaps in an end drop are not applicable for evaluation of the fuel basket.

An unlabeled summary table at the bottom of page 2.7-6 of the SAR shows that for both vertical drops, the gaps between the fuel basket and containment surface are “Not Applicable.” Staff has clearly stated during several meetings with Holtec, that maximum gaps are to be considered when evaluating the dynamic structural response.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-21 Provide 30 ft side drop LS-DYNA output files considering maximum gaps.

Holtec stated that a revised analysis was performed for the 30 ft side drop considering a maximum gap between the fuel assembly and support surface as well as the fuel basket and the containment boundary. Holtec did not provide these LS-DYNA output files which would allow the staff to complete its evaluation of this drop. Holtec stated on page 12 of the HI-2063584 Report that those files do exist, however, those files were not present on the external hard drive containing the LS-DYNA simulations.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-22 Provide an analysis considering appropriate gaps between the internal package contents including the inner surface of the containment boundary, the basket shims, the fuel basket, and the homogenized fuel bundles.

The staff disagrees with the simplified approach for calculating "bounding gaps" between the fuel assembly and basket, the basket and shims, the basket and containment boundary, and the fuel and containment boundary. Furthermore, the staff disagrees that for the end drop the gaps are "Not Applicable." The staff requests that both end drops and side drop be evaluated with the maximum possible gaps based on design drawings and tolerances. This would require that the gap for end drop between the fuel basket and the primary lid be at least 52 mm based on the engineering drawings (Drawing No. 4845, Sheet No. 3, Revision No. 2, Note No. 31, indicates 20 mm as the maximum gap. This value is not consistent with the numbers shown on the drawing). In addition, Holtec should include in this analysis the maximum radial gap to account for the space between the fuel basket and the basket shims. The maximum gaps within fuel chambers should also be simultaneously considered such that a maximum stackup of gaps is considered.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-23 Provide justification for using visual examination of contour plot fringe levels to report results.

Since nodal averaging is being used, contour plot fringe levels only give an approximate indication of the engineering quantity of interest for the region being investigated. This methodology is not a sufficiently rigorous analysis technique.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-24 Provide justification supporting Holtec's position that convergence is satisfied simply by noting that a model has more nodes and elements than a subjectively evaluated model found in the literature.

Literature citations of other investigators who have used LS-DYNA successfully to evaluate a specific engineering response does not demonstrate that the HISTAR-180 model is sufficiently robust to accurately simulate the engineering quantities being evaluated in this licensing action. A specific example would be the low quality mesh used in the monolithic shield which is evaluated in the side puncture drop. Another example is the variation in deformation response of the aluminum honeycomb when modeled with tetrahedrons versus hexahedrons having similar global element sizes.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-25 Provide the results of a revised puncture drop analyses that include appropriate node connectivity and mesh discretization near impact point.

For the vertical puncture drop, the results show a moderate amount of hourglassing in the puncture bar. In the case of the side puncture drop, the model exhibits severe hourglassing, apparent node connectivity problems, and an overly coarse mesh at the point of impact. With respect to node connectivity, it is not clear whether the applicant intended the monolithic shield cylinder layers to be separate entities as they are a single part within the LS-DYNA model.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-26 Provide a discussion supporting the dual designation for the primary and secondary lids as the containment boundary and/or water exclusion barrier.

The Holtec states that either closure lid can be a containment boundary with the other subsequently becoming a water exclusion barrier. It is unclear to the staff why Holtec is making this distinction in barrier designation.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-27 Provide justification supporting the statement “The Design Life of the HISTAR-180 system is conservatively set for 40 years.”

Given that there is insufficient data for Metamic as a structural material, the basis for a statement that the material has a 40 year design life is not clear.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-28 Provide the benchmarking report (Report No. 2073715, Rev. 0) that supports the following statement: “While the aluminum honeycomb is the prequalified crush material, polymeric crush materials with equivalent crush characteristics that also meet the environmental compatibility criteria may be qualified for use.”

It is unclear to the staff whether Holtec is requesting a safety assessment of polymeric materials as an alternative impact limiting material. If so, this information is needed for a complete and thorough review. Alternatively, if Holtec is not seeking a safety assessment for use of a polymeric impact limiting material at this time, then all references to this material should be removed from the SAR and other relevant documents associated with this licensing action.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-29 Provide justification supporting the determination that the angle used for the slapdown analysis (7 degrees) is a worst case orientation.

It is not clear to the staff the basis for this determination.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-30 Provide justification supporting the determination that the use of a coarse mesh of reduced integration thick shell elements with two integration points through thickness is sufficiently accurate for modeling the structural behavior of the

Metamic HT fuel basket behavior when compared with appropriately discretized solid elements.

This justification should include a sensitivity study to determine if thick shell elements are able to capture the structural response of the fuel basket accurately enough, given that the basket structural integrity is an integral part of the safety assessment. Specifically, the staff questions the reliability of using such a simplified coarse mesh which may preclude certain structural responses from occurring.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-31 Provide demonstration that the use of a coarse mesh of reduced integration thick shell elements with only a single element through the basket thickness with two integration points through thickness is sufficiently accurate for modeling the structural behavior of the Metamic fuel basket behavior when compared with appropriately discretized solid elements.

The staff requests a sensitivity study to determine if thick shell elements are able to capture the structural response of the fuel basket accurately enough, given that the basket structural integrity is an integral part of the safety assessment. Specifically, the staff questions the reliability of using such a simplified coarse mesh which may preclude certain structural responses from occurring.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-32 Provide a discussion justifying the use of only two integration points when using shell elements in all LS-DYNA models

The staff disagrees with the use of the default value of two integration points for shell elements due to the fact that the structural response may be inaccurate with such a simplified modeling approach.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-33 Provide justification for not including a failure strain for Metamic in the material model formulation.

The true stress/strain curve used in the LS-DYNA models has a strain data table that is at or exceeds 20% plastic strain with no defined failure strain for the material. Given that test data for elongation at failure is in the range of 6-8%, the staff questions the use of this material model input.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-34 Provide an analysis demonstrating that removing fabrication welds in the basket model, with the exception of the corners, is conservative.

Removing welds within the basket removes restraint that might otherwise induce stresses which exceed acceptable limits. It is unclear whether the change in the loading path, as well as the type of loadings on the Metamic plates, is conservative.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7, 10 CFR 71.71, and 10 CFR 71.73.

2-35 Supplement the SAR to include a discussion demonstrating compliance with the requirements of 10 CFR 71.43(e), 10 CFR 71.43(g), and 10 CFR 71.43(h).

The current SAR does not include sufficient information to allow the staff the ability to determine compliance with 10 CFR 71.43(e), 10 CFR 71.43(g), or 10 CFR 71.43(h).

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.43(e), 10 CFR 71.43(g), and 10 CFR 71.43(h).

2-36 Justify that the HI-STAR 180 can be used in a transport condition (*i.e.*, loaded with spent fuel).

This justification should address the current limited Metamic HT material property performance data for periods greater that one (1) year.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33 and 71.4.

2-37 Provide room temperature and elevated-temperature mechanical property test data (tensile, yield, elongation, Young's modulus, microhardness traverse, and Charpy impact or fracture toughness) for Metamic HT samples taken from three (3) orthogonal orientations in the final rolled plate product (*e.g.,* short-transverse and long-transverse direction in addition to the normally tested longitudinal direction). When performing Charpy or fracture toughness tests, consider the specimen and crack orientation combinations defined by Fig. A2.3 of ASTM E 616.

The staff believes that Metamic HT may be significantly anisotropic in microstructure and mechanical properties, with the optimum properties measured parallel to the rolling/extrusion direction. Since the fuel basket must withstand accident conditions which load the material in a variety of directions, knowledge of the anisotropy, if any, is necessary to properly evaluate the structural integrity of the basket design.

The purpose of the material testing is to adequately determine the behavior and properties of Metamic HT for its specific intended application. It is assumed that testing will employ samples of Metamic that are identical to the final plate form of the material that is used in a spent fuel basket.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-38 Provide photomicrographs of the Metamic HT final product as-rolled microstructure for the three (3) orthogonal directions mentioned in the previous question, in order to confirm the degree of microstructural anisotropy, if any. Additionally, provide a written evaluation of the photomicrographs describing microstructural features and their associated affect upon mechanical properties. The photomicrographs should clearly show the grain structure of the Metamic HT and allow comparison of grain size and morphology.

The staff believes that Metamic HT may be significantly anisotropic in microstructure and mechanical properties, with the optimum properties measured parallel to the rolling/extrusion direction. Since the fuel basket must withstand accident conditions which load the material in a variety of directions, knowledge of the anisotropy, if any, is necessary to properly evaluate the structural integrity of the basket design.

The purpose of the material testing is to adequately determine the behavior and properties of Metamic HT for its specific intended application. It is assumed that testing will employ samples of Metamic that are identical to the final form of the material that is used in a spent fuel basket.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-39 Provide room temperature and elevated temperature mechanical property test data (tensile, yield, elongation, Young's modulus, microhardness traverse, and Charpy impact or fracture toughness) for Metamic HT after one (1)-year exposure at the maximum normal design temperature. Include data for samples taken from three (3) orthogonal orientations in the final rolled plate material (*e.g.*, short-transverse and long-transverse direction in addition to the normally tested longitudinal direction). When performing Charpy or fracture toughness tests, consider the specimen and crack orientation combinations defined by Fig. A2.3 of ASTM E 616.

Due to the unique nature of Metamic HT and paucity of data, the staff cannot make any finding regarding the long term thermal stability of the material and any effect there might be on mechanical properties.

The purpose of the material testing is to adequately determine the behavior and properties of Metamic HT for its specific intended application. It is assumed that testing will employ samples of Metamic that are identical to the final form of the material that is used in a spent fuel basket.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-40 Provide photomicrographs of the Metamic HT microstructure, after the one (1)-year exposure at the maximum normal design temperature, for the three (3) orthogonal directions mentioned in the preceding related questions, in order to verify the degree of microstructural anisotropy. Additionally, provide a written evaluation of the photomicrographs describing microstructural features and their impact upon mechanical properties. The photomicrographs should clearly show the grain structure of the Metamic HT and allow comparison of grain size and morphology.

Due to the unique nature of Metamic HT and paucity of data, the staff cannot make any finding regarding the long term thermal stability of the material and any effect there might be on mechanical properties.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-41 Provide weld property data (tensile, yield, elongation, Young's modulus, microhardness traverse, and Charpy impact or fracture toughness) for Metamic HT welds (weld metal and heat-affected zone) for three (3) orthogonal directions as described in the preceding related questions, for the as-welded condition, at several temperatures from room temperature up to the maximum normal design temperature for the 180 cask. When performing Charpy or fracture toughness tests, consider the specimen and crack orientation combinations defined by Fig. A2.3 of ASTM E 616.

Due to the unique nature of Metamic HT and the paucity of data, the staff is unable to make any findings regarding the properties of welds in the as-welded condition, at room temperature, or at elevated temperature.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-42 As in the preceding related question, provide room temperature and elevated temperature weld property data (tensile, yield, elongation, Young's modulus, microhardness traverse, and Charpy impact or fracture toughness) for Metamic HT welds (weld metal and heat-affected zone) for three (3) orthogonal directions as described in the preceding related questions, after one (1)-year exposure at the maximum normal design temperature. When performing Charpy or fracture toughness tests, consider the specimen and crack orientation combinations defined by Fig. A2.3 of ASTM E 616.

Due to the unique nature of Metamic HT and the paucity of data, the staff is unable to make any findings regarding the properties of welds in the as-welded condition, at room temperature, at elevated temperature, or after long duration exposure to the maximum normal design operating temperature.

The purpose of the material testing is to adequately determine the behavior and properties of Metamic HT for its specific intended application. It is assumed that testing will employ samples of Metamic that are identical to the final form of the material that is used in a spent fuel basket.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-43 Provide photomicrographs representative of all the weld specimens in the two preceding questions. Additionally, provide a written evaluation of the photomicrographs describing microstructural features and their impact upon mechanical properties. The photomicrographs should clearly show the grain structure of the Metamic HT and allow comparison of grain size and morphology.

Due to the unique nature of Metamic HT and the paucity of data, the staff is unable to make any findings regarding the properties of welds in the as-welded condition, at room temperature, at elevated temperature, or after long duration exposure to the maximum normal design operating temperature.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-44 Provide neutron absorption and microstructural data that demonstrates that Metamic HT does not suffer any deleterious alteration of the boron carbide particles or their distribution within the aluminum matrix after one (1) year exposure at the maximum normal operating design temperature and maximum expected gamma and neutron fluence for the 180 cask. Consider the possibility of anisotropic microstructure and consequent neutron capture properties and include such in the testing plan. Show that the particle size and/or interparticle spacing is not adversely affected thereby reducing its neutron capture ability and/or resulting in streaming.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-45 Provide room temperature and elevated temperature mechanical property data for Metamic HT after exposure to the maximum design temperature and radiation (gamma and neutron) at the total fluence levels expected to accumulate after one (1) year of continuous exposure to spent fuel. Consider the possibility of anisotropic microstructure and account for such in the testing plan.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-46 Provide creep data for Metamic HT when exposed to radiation (gamma and neutron at fluence levels expected for a canister) at the maximum operating temperature. Consider the possibility of anisotropic microstructure and account for such in the testing plan.

The staff appreciates that some creep testing is presently in progress.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-47 Provide creep-rupture data for Metamic HT at the maximum design operating temperature. Provide the data for creep-rupture specimens taken from three (3) orthogonal directions as mentioned in the previous questions, in order to ascertain the degree of anisotropy, if any. The minimum duration of the creep-rupture tests should be around 10,000 hours so as to envelope the maximum allowable time [one (1) year] for a package to be in transportation.

The staff appreciates that some creep-rupture testing is currently in progress.

The purpose of the material testing is to adequately determine the behavior and properties of Metamic HT for its specific intended application. It is assumed that testing will employ samples of Metamic that are identical to the final form of the material that is used in a spent fuel basket.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-48 Provide data that demonstrates Metamic HT is immune to low temperature embrittlement.

The staff recognizes that conventional aluminum based alloys are immune to ductile-to-brittle material behavior with falling temperatures. However, the properties of Metamic HT are so far removed from conventional materials that assumptions based upon ingot metallurgy knowledge and experience are not a reliable guide for predicting the performance of Metamic HT. Additionally, some of the data submitted with the SAR shows some unexpected temperature-sensitivity that demands further exploration.

The purpose of the material testing is to adequately determine the behavior and properties of Metamic HT for its specific intended application. It is assumed that testing will employ samples of Metamic that are identical to the final form of the material that is used in a spent fuel basket.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-49 Provide additional test data and evaluation to reconcile the elongation-to-failure data versus the shear fracture percentage reported for Metamic HT.

According to Section 3.1 of Report HTA 06911, the elongation-to-failure for Metamic HT decreases with increasing temperature. The NRC staff views this phenomenon as uncharacteristic of typical engineering materials. In addition, the trend of <u>decreasing</u> elongation at failure with increasing temperature, reported in Section 3.1 of Report HTA 06911, appears to contradict the trend of <u>increasing</u> shear fracture with increasing temperature, measured with Charpy impact tests in Section 3.3 of Report HTA 06911.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-50 Provide a discussion to explain the variations in the reported elastic modulus for Metamic HT when using the ASTM E111-97 testing specification. These values are reported in Attachment 1 of report HTA 06911.

Accurate and precise measurements of the elastic modulus are critical for the evaluation of Metamic HT as a structural material for a spent nuclear fuel basket. Significant variations (~15%) in the measured elastic modulus were reported for different samples tested at the same temperature using the ASTM E111-97 testing specification.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-51 Provide a discussion explaining the amount of data that will be sufficient (statistically significant) to describe the Young's modulus of Metamic HT with an adequate degree of confidence.

The mechanical properties of Metamic HT must be sufficiently characterized before it can be accepted for use as a structural basket material in a spent nuclear fuel cask. Currently, the Young's modulus of Metamic HT is bounded by only two samples tested by ASTM E111-97. Unlike toughness, (K_{IC}, Charpy impact energy or strain to failure) where only the lower bound is taken into consideration during engineering design, the Young's modulus of a material must be precisely known in order to adequately describe the material's behavior under mechanical loading.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-52 Provide a discussion explaining the reason(s) for removing "conspicuously spurious data" from the ongoing creep testing program.

When Metamic HT creep test data was first examined by the staff, several additional creep specimens were under test. In later versions of the Metamic HT report, fewer test specimens appeared in the data set and a note in the Metamic report mentioned "conspicuously spurious data" as being removed. Data, even if apparently anomalous, should not be discarded unless extenuating circumstances exist that would render the data invalid.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7(a).

2-53 Provide a discussion explaining the amount of impact data that will be sufficient (statistically significant) so that a lower bound for the impact properties of Metamic HT can be established to an adequate degree of confidence.

The mechanical properties of Metamic HT must be sufficiently characterized before it can be accepted for use as a structural basket material in a spent nuclear fuel cask.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5) and 71.43(f).

2-54 Discuss the effect the maximum design accident (fire) temperature would have on Metamic HT base material and weld zone material. Provide room temperature and elevated temperature mechanical property test data (tensile, yield, elongation, Young's modulus, microhardness traverse, and Charpy impact or fracture toughness) for Metamic HT base material and weld zone material after a 30 minute exposure at the maximum design accident (fire) temperature. Include data for samples taken from three (3) orthogonal orientations in the final rolled plate material (*e.g.,* short-transverse and long-transverse direction in addition to the normally tested longitudinal direction). When performing Charpy or fracture toughness tests, consider the specimen and crack orientation combinations defined by Fig. A2.3 of ASTM E 616.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7(a).

2-55 Provide photomicrographs of the Metamic HT base material and weld zone material microstructure, after a 30 minute exposure at the maximum design accident (fire) temperature, for the three (3) orthogonal directions mentioned in the preceding related questions, in order to verify the degree of microstructural anisotropy. Additionally, provide a written evaluation of the photomicrographs describing microstructural features and their impact upon mechanical properties. The photomicrographs should clearly show the grain structure of the Metamic HT and allow comparison of grain size and morphology.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7(a).

2-56 Provide data which shows that these SAR specified bolt materials (SA-193-B7, SA-564-630, and SA-705-630), used for the canister lid, have sufficient ductility and impact resistance under the design accident conditions at -20 degrees Fahrenheit (^{o}F).

SAR Section 2.1.2.2, page 2.1-12, states:

> "The cask closure plate bolts may be fabricated from Code-sanctioned materials such as SA-193-B7, SA-564-630, SA-705-630, or SB-637-N07718. Section 5 of NUREG/CR-1815 [2.1.9] indicates that bolts are generally not considered susceptible to brittle fracture."

The staff is unable to find, based upon the above SAR statement and ASME specifications, that all those materials are immune to NDTT issues or have sufficient toughness to meet design accident conditions. The staff notes that NUREG-1815 also concludes, in the same paragraph quoted above:

> "However, in cases where a particular bolt is determined to be a fracture-critical component, the toughness requirements for that bolt should be specified at the same category level as other components of the system."

Since the bolts in question are part of the containment boundary, demonstration of their NDTT performance and toughness is necessary. The material specifications for the SA-193, SA-564, and SA-705 do not require Charpy impact testing, either at all, or at lower temperatures, as a mandatory part of the specification (some are supplementary tests). Additionally the toughness requirements, where stated, appear to be inadequate compared to the canister material. Therefore, Charpy testing and ductility data, at low temperature, would be necessary to ensure the materials specified are adequate for the design conditions. Absent these tests, there is no assurance of the bolting material performance. The staff accepts that SB-637-N07718 is immune to NDTT issues and has adequate toughness.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51(a)(2).

2-57 Provide a discussion that demonstrates that the SA-352-LCC gamma shield material has adequate ductility and impact resistance at -20 ^{o}F to withstand the impact loads that would occur during a design accident basis 30-foot drop (with impact limiters), and the one (1)-meter drop puncture-test.

SA-352-LCC is specified to require a minimum Charpy impact energy of 15 foot-pounds (ft.-lbs.) at -50 ^{o}F. It is not clear that the impact energy absorbed (15 ft.-lbs.) translates to sufficient ductility and energy absorption to prevent cracking of the gamma shield with resulting radiation streaming.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51(a)(2).

2-58 The following minor editorial errors should be corrected:

1. Page 1.B-2 of the SAR refers to a LLNL report as Reference 2.7.10. The correct Reference is 2.7.11.

2. Table 2.6.2 appears mislabeled, References for F-32 figures and F-37 figures appear to be transposed.

3. Page 2.1-9 of the SAR, Section 2.1.2.2 Acceptance Criteria, (i) Containment Boundary, (a.) Design Pressure, second line, …"closure lids, and the containment shell **should** meet stress intensity limits of Subsection NB…" Replace the word "should" with "must."

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7.

3.0 THERMAL EVALUATION

3-1 Provide the definition of the maximum temperature of secondary closure lid shown in Table 3.1.3. Justify this maximum secondary closure lid temperature is representative for the entire secondary closure lid and satisfy the temperature limit during regulatory fire analysis. In addition, provide the manufacturer recommended temperature limits for secondary closure lid seal in regulatory accident condition.

In Table 3.1.3 of the SAR, the maximum temperature for secondary lid during fire analysis is 336 ^{o}C, which satisfies the temperature limit (371 ^{o}C) listed in SAR Table 3.2.10. However, the staff checked the FLUENT data file for 30-minute fire and the maximum temperature of secondary lid was around 420 ^{o}C. According to the thermal analysis report (HI-2073649) Table 7.3, the maximum temperature is the maximum section average temperature. Provide the definition of this section average property and justify the maximum section average temperature (336 ^{o}C) sufficiently represents the secondary closure lid and satisfies the temperature limit. In Note 1 of SAR Table 3.2.12, Holtec claimed the primary and secondary lid seals temperature limits bounded the manufacturer recommended temperature limits. Provide these manufacturer recommended temperature limits.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.73(4).

3-2 Provide a discussion justifying the initial/boundary conditions and material properties for neutron shield (Holtite-B) and impact limiter during regulatory fire analysis and post-fire cooldown analysis.

Holtec assumes the neutron shield is lost during the 30-minute fire accident and therefore is not existent in post-fire cooldown analysis. According to the FLUENT data deck, the Holtite-B material is assumed intact during the 30-minute fire and the maximum temperature of the neutron shield is 649 ^{o}C. Holtec did not model the process during the 30-minute fire period when temperature exceeded the limit. This maximum temperature was in turn used as an initial condition for post-fire cooldown analysis. In the post-fire analysis the neutron shield material was switched into “air-solid” material with same initial temperature. This approach lacks consistency in thermal properties and balance of stored energy. The internal energy stored in the neutron shield after fire is expected higher than that of air-solid material due to different density and heat capacity. The applicant should consider the density and heat capacity effects in the material transition approach and justify the assumed physical properties and initial conditions are conservative in the analysis. Same issue applies to the impact limiters. The temperature used as initial condition for the impact limiter in post-fire analysis was taken from metal.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.73(4).

3-3 Provide the derivation of the assumed convective heat transfer coefficient from the Sandia laboratory report for large pool fires. Also, provide the ratio between convective heat transfer and radiation heat transfer and justify the convective heat transfer coefficient is applicable for HI-STAR 180 configuration.

The convective heat transfer coefficient used in the fire analysis 4.5 BTU/ft^{2} hr ^{o}F is according to the Sandia National Lab experiment results. However, the Sandia report provided heat flux measurement instead of heat transfer coefficient. The heat transfer coefficient used in the SAR is a derived value. Holtec should provide the derivation. In addition, based on the FLUENT calculation, Holtec should provide the ratio between convective heat transfer and radiation heat transfer and compare it to the Sandia Lab experiment results.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.73(4).

3-4 Provide the effect of basket shim on the basket to cavity radial differential expansion analysis and perform sensitivity study of Helium gap dimension on the temperature distribution.

The radial basket-to-cavity differential expansion analysis was performed in Section 7.4 of Thermal Analysis of the HI-STAR 180 (HI-2073649). An Aluminum basket shim is located between the basket and cavity and it has direct contact with the fuel basket. In the thermal analysis, 4 mm Helium gaps are modeled for shims-to-cavity and shims-to-basket respectively. The Holtec should analyze the effect of basket shim on the basket to cavity radial differential expansion analysis. In SAR Table 3.4.2 minimum cold basket-to-cavity gap of 6 millimeters (mm) is listed. It is different than the 4 mm used in thermal analysis. The applicant should provide a sensitivity study on the dimension of two Helium gaps in thermal analysis to ensure enough thermal margins are preserved for all components.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33, 10 CFR 71.71(c)(1).

3-5 Provide the results of a lid seal region detail analysis and justify the secondary lid seal temperature model is conservative in regulatory fire analysis.

In Table 7.3 of Thermal Analysis of the HI-STAR 180 (HI-2073649), the primary and secondary lid seals temperature (350 ^{o}C) was reported at the seal location radius according to notes 3 and 4. The lid seal region includes the grooves, metallic seal, and residual helium. The contact resistance and the seal material property should affect the lid seal temperature in the thermal analysis. Currently no detail lid seal region is modeled in the SAR and the lid seal temperature is based on interpolation. Both lid seals are credited for containment and criticality safety and the applicant should demonstrate that the seals will possess an acceptable integrity during fire condition. In light of the small margin (21 ^{o}C) toward the limit (371 ^{o}C), Holtec should analyze the lid seal region in detail and demonstrate the lid seal temperature complies with the limits.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.73(4), 71.55.

3-6 Provide information clarifying the cask and impact limiter surface maximum temperatures between the SAR and FLUENT data file.

In SAR Table 3.1.3 and Thermal Analysis of the HI-STAR 180 Table 7.3, the listed temperatures for cask surface (668 ^{o}C) and impact limiter surface (688 ^{o}C) during fire condition are different than the temperatures in the FLUENT data file - 676 ^{o}C for both cask and impact limiter. The applicant should clarify the data inconsistency.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.73(4).

3-7 Provide the temperature limit of impact limiter and justify the impact limiter temperature satisfies this limit under Normal Conditions of Transport (NCT).

Table 3.2.10 of the SAR does not include a temperature limit for the impact limiter material (AL-STAR 180). This limit is needed to evaluate the thermal performance of the impact limiter under NCT.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33 and 71.71.

3-8 Provide the actual thermal emissivity value for basket material METAMIC under the operating condition of HI-STAR 180.

According to Section B3.1 of Thermal Analysis of the HI-STAR 180 Report (HI-2073649), Holtec stated that the thermal emissivity (0.5) of the fuel basket material (METAMIC) is a conservative understated value. Holtec stated that the actual value is greater than 0.5 through a reference. Holtec should provide the reference and the actual emissivity value under the operating condition of HI-STAR 180.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33.

3-9 Provide a discussion addressing the response of the aluminum alloy basket shims to the normal maximum operating temperature of approximately 500 ^{o}F, considering the mechanical properties and creep properties of the alloy at that temperature with exposure duration up to one year.

The staff is concerned that prolonged exposure to the design temperature will adversely affect the ability of the basket shims to perform their thermal function (due to creep-induced distortion) and that distortion of the shims may adversely affect the fuel basket stress/strains under accident conditions.

Note: The SAR specifies different temperatures in different sections. SAR Table 3.1.1 specifies the normal maximum operating temperature is 461 ^{o}F. Table 3.1.3 specifies the maximum accident temperature as 534 ^{o}F. SAR page 3.2-13 specifies 500 ^{o}F and 752 ^{o}F respective maximum normal and accident temperature limits. For a stainless steel, this difference might not be significant. However, for the proposed aluminum alloy, these temperature differences may be significant and should be considered.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7(a).

3-10 Provide a discussion addressing whether the maximum design accident (fire) temperature would have any effect on the aluminum alloy basket shims beyond that analyzed in the preceding question, considering the reduced mechanical properties that would result from exposure to the higher design accident temperature.

Note: The SAR specifies different temperatures in different sections. SAR Table 3.1.1 specifies the normal maximum operating temperature is 461 ^{o}F. Table 3.1.3 specifies the maximum accident temperature as 534 ^{o}F. SAR page 3.2-13 specifies 500 ^{o}F and 752 ^{o}F respective maximum normal and accident temperature limits. For a stainless steel, this difference might not be significant. However, for the proposed aluminum alloy, these temperature differences may be significant and should be considered.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7(a).

4.0 CONTAINMENT

4-1 Revise the application to clearly identify the containment system (i.e., containment boundary) for the package that meets the requirements of 10 CFR 71.51, and describe the testing of the containment system that meets the standards of ANSI N14.5-1997.

The SAR describes two closure lids; however, the leakage testing performed for each lid does not appear to meet the standards in ANSI N14.5-1997. Since the package design specifies two redundant closure lids, both closure systems should be identified as part of the package containment system and criticality safety system for moderator exclusion. The closure systems should independently meet the requirements of 10 CFR 71.51 and the standards in ANSI N14.5-1997 with respect to meeting the leak-tight design leakage rate and leakage testing sensitivity.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51 and 71.55.

4-2 Revise Table 4.1.1 to clearly state the numerical acceptance criterion and test sensitivity for the package leakage tests.

Table 4.1.1 is not clear regarding the leakage rate acceptance criteria and test sensitivities for the package leakage tests. The table should be revised to specify the maximum allowable leakage rate, i.e., $1x10^{-7}$ ref-cm^3/s for leaktight, and a minimum test sensitivity of $5x10^{-8}$ ref-cm^3/s for the acceptance criterion and the test sensitivity, consistent with ANSI N14.5-1997.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

4-3 Provide a discussion clarifying the discrepancy between Section 2.2.1.1.6 and HI-2063563 Rev. 1 Page C.4 “HI-STAR 180 Seal Specification (Safety Significant Information)” regarding the high nickel seal material after an extended period storage. Also, justify the length of 20 years as the criteria for high nickel alloys, discuss its use in Section 4.1.3.1, and add this high nickel requirement in the engineering drawings and acceptance test in Chapter 8 of the SAR. This question should be considered and addressed independently of Question 1-1, related to compliance with the intent of 10 CFR Part 72; and Question 2-38, related to current limited Metamic HT material property performance data for periods greater that one (1) year.

Section 2.2.1.1.6 states, "When casks are to be transported after an extended period of storage (20 or more years), only high nickel alloys (X750 and 718) shall be used for the seal shell material." While in HI-2063563 Rev. 1 Page C.4 "HI-STAR 180 Seal Specifications (Safety Significant Information)" it is stated, "For long-term storage mode, only high nickel alloys (X750 and 718) may be used for seal shell and spring." Holtec should specify the technical basis that assures the variable materials specifications assure seal integrity after extended storage.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

4-4 Revise Table 4.4.1 to include an additional column that provides the maximum allowable leakage rate, i.e., $1x10^{-7}$ ref-cm^3/s, for the fabrication leak rate tests, and the appropriate test sensitivity for the pre-shipment leakage test for instances when the seal has been previously tested and when a new seal is used.

Table 4.4.1 is not specific with respect to allowable leakage rates and test sensitivities. Note that the pre-shipment leakage rate tests must demonstrate the maximum allowable leakage rate (i.e., $1x10^{-7}$ ref-cm^3/s), if the containment system seal is replaced prior to the shipment, and this should be noted in the table (see ANSI N14.5-1997, Section 7.4 and 7.4.4).

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

5.0 SHIELDING EVALUATION

5-1 Provide a detailed discussion and footnotes in the SAR for the parameters listed in Tables 1.2.10. This discussion should clarify how: (1) the burnup, cooling time, and enrichment values in Tables 1.2.9 and 1.2.10 are derived {update the SAR and the tables to clarify the bases, as appropriate}; (2) the burnup, cooling time and enrichment values are interpolated between entries during loading operations; and (3) the user verifies individual fuel assemblies meets the maximum decay limits specified for each region.

Based on the information provided in the SAR., it is not clear if the source terms and decay heat loads for each combination represent the limiting heat load for each corresponding loading region, limiting dose rates from the shielding analyses, or limiting thermal conditions from the thermal analyses.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.47, 71.51, and 71.73.

5-2 Provide clarification of the terms/phrases such as, "*single full power cycle*" and "*the power level and core conditions remained constant over the duration of the burnup unless otherwise stated*" in the last paragraph of Section 2 (General Methodology, page 3) of Holtec Report No. HI-2073653 "Source Terms for the HI-STAR 180."

In the context when a full power cycle is used, why is it that no credit is taken for downtime between cycles. What is the *duration* of the full cycle? List and explain the *core conditions* that remained constant over the *duration* of the burnup.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.31, 71.33, and 71.47.

5-3 Justify the use of SAS2H/ORIGEN-S codes with 44groupndf5 cross section library in performing source term calculation for UO_2 fuel assemblies up to maximum burnup of 66 GWd/MTU and for MOX assemblies up to maximum burnup of 61.5 GWd/MTU.

Tables 1.2.8 through 1.2.10 of the SAR indicate that the maximum burnup for F-32 and F-37 loading patterns include UO_2 assemblies having maximum burnup up to 66 GWd/MTU and MOX assemblies having maximum burnup up to 61.5 GWd/MTU. Tables 5.2.4, 5.2.6, and 5.2.7 of the SAR indicate source terms calculated for UO_2 and MOX assemblies with burnups of 66 GWd/MTU and 61.5 GWd/MTU, respectively.

Point depletion codes, such as SAS2H/ORIGEN-S combination, have been validated for PWR fuel assays with a maximum burnup of 46.46 GWd/MTU. A reconstituted fuel assembly from H. B. Robinson plant was irradiated to 72.9 GWd/MTU. This reconstituted fuel assembly that consisted of 5 fuel rods mixed with fresh fuel rods and partially irradiated gadolinia rods, introduces considerable assembly heterogeneity near the end of irradiation. This is significantly different from a typical commercial reactor fuel which tends towards more uniform assembly compositions near the end of irradiation. Therefore this high burnup assembly is not appropriate for benchmarking the depletion code for high burnup fuel. (Reference: NUREG/CR-6701, *Review of Technical Issues Related to Predicting Isotopic Compositions and Source Terms for High-Burnup Fuel.*)

With the current trend towards higher enrichment and higher burnup fuel, efforts are underway for the acquisition of additional experimental data to support validation of the depletion code in the high burnup region. Currently several programs are in progress to obtain these data in the United States. In the meantime it may be necessary to impose additional safety margin to account for the uncertainties in the calculations. The extra safety margin may be determined based on modeling analyses, loading curves and published sensitivity analyses.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.47 and 71.51.

5-4 List appropriate uncertainties associated with each of the maximum dose rates shown in Tables 5.1.1 through 5.1.8 of the SAR from the calculations. These uncertainties should be overall uncertainty which is cumulative of the uncertainties in plant fuel parameters, plant operating parameters, source calculations, and the shielding evaluations from MCNP.

Tables 5.1.1 through 5.1.8 list maximum dose rates at various distances from the HI-STAR 180 packaging system for both normal and accident conditions without specifying the uncertainties associated with the calculations. Section 5.4.1 of the SAR states that "*These parameters were chosen so that the relative error for the dose rates presented in this chapter was typically less than 4%.*" In view of the fact that the dose rates listed in Tables 5.1.5 through 5.1.8 shows a margin relative to the regulatory limit in the range of 3.2% and 14%, the staff requires applicants to specify the uncertainties in the dose rates. In order to determine the margin of safety in the dose calculations, uncertainties corresponding to each of the items listed in the above tables are required.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.47 and 71.51.

5-5 Provide a discussion justifying that the source distribution of high burnup fuel is not reconfigured enough after accident conditions sufficient to exceed the 1 rem/hour regulatory limit.

The calculated accident dose rate in Table 5.4.5 (Table 5.1.8) appears to be within 4% of the regulatory limit of 10 CFR 71.51. It is not clear, for example, if the linear source term in localized areas will not be increased as a result of potential damage to HBF, and raise the accident dose rate greater than 4%.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

5-6 Provide a detailed description of the two-step process to calculate dose rates for each energy group and basket location. Clarify whether this two-step process is a response function method and how this method is validated with direct MCNP calculations described in Section 5.4 of the SAR.

The SAR should include the calculation description such as, summation process, or formula that explains how the method is used to sum doses; the axial and azimuthal locations that were considered, the method for statistically combining standard deviations, and how the burnup profile and adjustment for axial neutron and gamma source terms are utilized in the method. In addition, the two-step method should be validated against direct MCNP calculations for representative burnup, cooling, enrichment, and preferential combinations in the HI-STAR 180 baskets.

This information is needed to verify compliance with 10 CFR Part 71 shielding requirements.

5-7 Provide the dose rates for MOX vectors MV-2, and MV-3 in Table 6 of HI report HI-2073655 where the dose rate comparison are performed to determine the bounding MOX vector.

Section 7.1 of Calculation Report HI-2073655 describes the calculation process for dose rates for the four MOX vectors MV-1, MV-2, MV-3, and MV-4 and concludes that the dose rates for MV-1 is bounding. Table 6 of the calculation report does not contain dose rates for MOX vectors MV-2, and MV-3 of F-32 basket loading patterns B, C, and D and for vectors, MV-2 and MV-3 of F-37 basket loading patterns A, B, and C.

This information is required for staff review for confirmation of bounding configuration to determine shielding to comply with 10 CFR 71.47 and 71.51.

5-8 Provide the specific dimensions of the detector configurations for the axial and azimuthal segments for the side, top, and bottom of the cask, as shown in Figures 5.1.1 and 5.1.2. Also, clarify if the accident dose calculation from the side of the cask is one meter from the neutron shield radius, or one meter from the cask body radius.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

5-9 Provide the following information regarding the analyses of loading pattern defined in Section 1.2.2 of the SAR:

(a) Clarify, if the burnup, cooling time, and enrichment combinations for each basket region were calculated using the two-step process, and if dose rates were compared for all dose locations.

(b) Clarify, if the burnup, cooling, and enrichment combinations for each basket region exceed the total or individual decay heat loads specified for the fuel assemblies.

(c) Justify why the normal condition dose rate at two (2) meters is used to determine alternative burnup and cooling combinations rather than the accident conditions.

(d) Provide the results of the bounding cases with maximum burnup and minimum cooling times for normal and accident conditions.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.31, 71.33, 71.47, and 71.51.

5-10 Provide a discussion explaining the basis for the four criteria for the MOX fuel isotopic composition in Table 1.2.4 of the SAR and the three criteria for the MOX fuel isotopic characteristics in Table 1.2.5 of the SAR.

Section 1.2.2 of the SAR states, "*For MOX assemblies, four sets of limits are specified in Table 1.2.4, and three sets are specified in Table 1.25. A MOX assembly meeting the limits in one of the sets in each table is acceptable for transport.*" The staff expects the SAR to explicitly state the basis for the selection of these sets and to include the basis in the SAR.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.31 and 71.33.

5-11 Provide clarification of the NOTE below Table 5.2.3 of the SAR regarding the values presented in the table and the bounding vectors.

The NOTE below Table 5.2.3 states that "*the values presented in this table do not represent the bounding vectors, but rather the values utilized in the source term calculations.*" Why are the bounding vectors not used in the source term calculations?

This information is needed to verify whether the source calculation is performed using the most appropriate isotopic composition in the shielding evaluation to comply with 10 CFR 71.47 and 71.51.

6.0 CRITICALITY EVALUATION

6-1 Revise the criticality evaluation in Section 6.0 of the SAR to address how burnup values are assigned to assemblies to be loaded in canister positions analyzed using burnup credit. Additionally, revise the application to describe the physical burnup measurement that will be used to confirm the reactor record burnup value prior to loading in canister positions analyzed using burnup credit.

NRC Interim Staff Guidance 8, "Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks," Revision 2 (ISG-8), states that:

> *"The assembly burnup value to be used for loading acceptance (termed the assigned burnup loading value) should be the confirmed reactor record value as adjusted by reducing the record value by a combination of the uncertainties in the record value and the measurement."*

However, the application does not appear to address how burnup values are assigned to assemblies, or any uncertainties that are to be applied to the reactor record value for burnup. Additionally, the application does not address pre-shipment confirmatory burnup measurements that are also recommended by ISG-8 (see Certificate of Compliance No. 71-9261, Condition 5.(b)(1)(i), for the previously approved HI-STAR 100 MPC-32 canister). The application should be revised to address these two recommendations.

This information is required to ensure that the package design meets the criticality safety requirements of 10 CFR Part 71.

6-2 Revise the criticality analysis to clarify how the bounding irradiation parameters discussed in Section 6.B.2.1, and listed in Table 6.B.1, were determined for fuel to be loaded into the F-37 canister under the burnup credit assumption. Additionally, revise the application to describe how the fuel assemblies selected for loading in locations analyzed using burnup credit are shown to meet these operating limits during their in-core depletion.

It is not clear how the core operating parameters used in burnup credit evaluations, given in Table 6.B.1, were determined. The application should provide evidence that the selected parameter limits are bounding for the fuel to be loaded in the cask. Also, the application should provide a description of the means for verifying that fuel assemblies to be loaded in the package do not exceed any of the stated operating limits (see Certificate of Compliance No. 71-9261, Condition 5.(b)(1)(h), for the previously approved HI-STAR 100 MPC-32 canister).

This information is required to ensure that the package design meets the criticality safety requirements of 10 CFR Part 71.

6-3 Revise the burnup credit analysis in Appendix 6.B of the SAR to consider partial flooding of the F-37 basket in connection with a bounding axial burnup distribution.

Section 6.3.4.2 of the SAR demonstrates that partial flooding of the cask under the fresh fuel assumption is less reactive than full flooding of the cask. However, this same analysis was not performed for the burnup credit analysis of the F-37 basket. Partial flooding of the less-burned ends of the fuel assemblies in the basket with a bounding axial burnup profile may produce a condition that is more reactive than the fully flooded, axially constant burnup profile. The burnup credit analysis should be revised to consider this condition.

This information is needed to ensure that the applicant has identified the most reactive credible configuration consistent with the chemical and physical form of the material, per 10 CFR 71.55(b).

6-4 Provide analyses which include or exclude all data from the Takahama and Yankee Rowe samples and perform the appropriate statistical trending analyses.

The argument for selectively excluding the data from the two Takahama samples taken from the end of active fuel zone due to a limitation in CASMO depletion code is not valid. Establishing the code bias means quantifying the code limitations, among other factors. Furthermore, CASMO is used to determine the isotopic inventory of spent fuel assemblies with 32-zone burnup profiles. The code bias needs to include data from the representative end regions.

With respect to Yankee Rowe data, the argument presented for selective exclusion of certain data points (i.e., suspected errors in experimental documentation), appears to be a valid argument for excluding all data points from this set. It is not possible, without additional information regarding these experiments, to make a determination that different samples from the same assembly are more or less correct than others.

This information is needed to ensure that the applicant has identified the most reactive credible configuration consistent with the chemical and physical form of the material, per 10 CFR 71.55(b).

6-5 Provide an analysis showing the impact of fuel assembly misloads in the HI-STAR 180 burnup credit analysis for the F-37 basket.

This analysis should show the sensitivity of the design to misloads when meeting the requirements of 10 CFR 71.55(b). One of the benefits of burnup measurements is to provide assurance that fuel is not misloaded into the HI-STAR 180. The results of this analysis will be included in the factors used to assess the extent of burnup measurements needed for this design.

This information is needed to ensure that the applicant has identified the most reactive credible configuration consistent with the chemical and physical form of the material, per 10 CFR 71.55(b).

7.0 OPERATING PROCEDURES

7-1 Provide a revised Chapter 7 of the SAR to include the proper installation of packaging components and the proper assembly of the package prior to shipment.

Chapter 7 includes steps needed for the loading of the package and its preparation for shipment. It appears that some of the packaging components are not explicitly addressed in Chapter 7. In addition, it appears that some steps are not complete. For example:

a. It appears that a step in Section 7.1.2.2 “Cask Closure” should be included to address the installation of the secondary closure lid inter-seal test port plug.

b. It appears that Section 7.1.2.2.4, should describe how the secondary closure lid access port plug seal, which is part of the containment system, will be leak tested in conformance with ANSI N14.5-1997. Clarify the method for leakage testing, and the acceptance criterion for the leakage test. Note that if the seal is replaced, the test must demonstrate that the seal leakage is no more than $1x10^{-7}$ ref-cm^3/s.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51 and 71.87.

7-2 Provide a revised Chapter 7 of the SAR that specifically addresses the package leakage tests that will be performed prior to shipment.

The information in Chapter 7 is not clear with respect to the leakage testing of the containment and criticality safety system seals for the redundant closure lids. Revise Sections 7.1.2.1.12 and 7.1.2.2.4 to clearly state the numerical allowable leakage rate acceptance criterion and leakage rate test sensitivity.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

7-3 Provide clarification of the term “sufficient concentration” of helium in step 12 and the method for which the gas is introduced into the space beneath the covers prior to testing the plugs.

The application should demonstrate that an adequate amount of helium will actually exist to assure any leakage would be identified during testing of the plugs.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

7-4 Provide a revised Table 7.1.1, “HI-STAR 180 Package Torque Requirements,” to include numerical torque values for primary and secondary closure lid bolts and plugs torque values labeled as “Torque values per seal manufacturer recommendation.” Also revise the engineering drawings to include numerical torque values.

Table 7.1.1 is not specific with respect to the numerical torque values for the primary and secondary closure lid bolts and plugs. The numerical torque values are also not included on the engineering drawings.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33.

7-5 Provide a discussion that justifies the various methods proposed for testing the primary closure lid that will verify its integrity after several years of storage.

Provide the acceptance criteria and a description of equipment for each method that is proposed for testing the primary closure lid. Clarify how testing through the second closure lid port tests the integrity of the primary closure lid.

Both closure systems should be identified as part of the package containment safety system and criticality safety system for moderator exclusion. The closure systems should independently meet the requirements of 10 CFR 71.51 and the standards in ANSI N14.5-1997 with respect to meeting the leak-tight design leakage rate after long-term storage.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51 and 71.55.

7-6 Provide a revised Section 7.4 of the SAR, with the statements indicating that the secondary closure lid can be designated and tested as the containment boundary if the primary closure lid seal integrity is "uncertain" removed.

Both lids are credited for containment and criticality safety and the application should demonstrate that the primary lid will possess an acceptable integrity regardless of long or short term loading options.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51 and 71.55.

7-7 Provide a revised Section 7.4 and corresponding sections in Chapter 8 to include package operations that will be used to ensure that the containment system seals are appropriate for the length of time in storage prior to transport. This question should be considered and addressed independently of Question 1-1, related to compliance with the intent of 10 CFR Part 72; and Question 2-38, related to current limited Metamic HT material property performance data for periods greater that one (1) year.

Section 2.2.1.1.6 states "When casks are to be transported after an extended period of storage (20 or more years), only high nickel alloys (X750 and 718) shall be used for the seal shell material." When replacing the seals during package operations it is necessary to know the length of storage time prior to transport so the appropriate type of seal material can be used.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

7-8 Provide a revised Chapter 7 of the SAR that includes a written caution or a proposed Certificate of Compliance (CoC) condition that would prevent oxidation of the cladding or fuel during the dewatering/flooding step of a canister loading/unloading operation.

The loading procedure as it appears in the SAR describes use of the Holtec forced helium drying system or the vacuum drying system, which implies but does not specifically state that the fuel will not be exposed to air for a significant period. Holtec has previously provided satisfactory SAR and Technical Specification (TS) wording in this regard for some storage-only designs such as the HI-STORM 100. These storage canister SAR and TS sections appear to contain appropriate provisions for incorporation into the HI-STAR 180 SAR and CoC.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7(a), 71.33(a)(5) and 71.43(f).

7-9 Provide the method of evaluating site specific “Time-to-Boil’ criteria in procedure step 3 and demonstrate how the users avoid violating the criteria. Provide an analysis to show the cladding temperature limits are not exceeded during drying operation for HI-STAR 180, either Forced Helium Dehydration or vacuum drying method according to the procedure steps 9 and 10. The analysis should specify any time limits and additional controls in the operation to ensure cladding integrity.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33.

8.0 ACCEPTANCE CRITERIA AND MAINTENANCE PROGRAM

8-1 Provide a revised Section 8.1.4 of the SAR that specifies the type of leakage rate test, the component tested, the type of leakage test from ANSI N14.5-1997, the leakage rate acceptance criterion, and the leakage rate test sensitivity.

In Section 8.1.4 include a table that shows the type of leakage rate test, the component tested, the type of leakage test from ANSI N14.5-1997, the leakage rate acceptance criterion, and the leakage rate test sensitivity. Adequate description of the containment system boundary leakage rate tests is necessary to ensure that acceptance and maintenance tests are being performed in accordance with ANSI N14-5.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

8-2 Provide a discussion that justifies the reason for establishing a less sensitive leakage test for the primary and secondary lid when it is designated as a “moderator exclusion barrier.” Also, specify the criteria the user should consider when specifying which lid is the barrier.

Since credit is assumed for both lids in Chapters 1 and 6 as part of the package containment system and criticality safety system for moderator exclusion. Thus, each closure system should independently meet the requirements of 10 CFR 71.51 and the standards in ANSI N14.5-1997 with respect to meeting the design leakage rate and leakage testing sensitivity.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51 and 71.55.

8-3 Provide a revised Section 8.2.2 of the SAR that specifies the test sensitivity of the pre-shipment leakage tests.

Section 8.2.2 specifies the performance of a leakage test, but the test sensitivity is not specified.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

8-4 Provide either: (1) confirmation that the inner lid containment system seals (primary closure lid inner seal and vent and drain seals) are tested prior to shipment in a manner consistent with ANSI N14.5-1997, or (2) justification for not testing the inner lid containment system seals prior to shipment consistent with ANSI N14.5-1997.

From the information provided in the SAR, it is not clear that the inner lid containment system seals are tested prior to shipment, consistent with ANSI N14.5-1997.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51.

8-5 Provide a revised Section 8.1.3.1 of the SAR to correct the following apparent editorial error. Section 8.1.3.1, third paragraph, last sentence, "ANSI N14.5" should be "ANSI N14.6."

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.7.

8-6 Provide a revised Section 8.1.6 of the SAR that includes shielding integrity and effectiveness tests an acceptance tests.

The staff does not agree with the statement in Section 8.1.6 that states, "[s]*hielding tests are not required for the assembled packaging…"* The integrity of the neutron and gamma shielding materials should be tested to verify the material composition, boron concentration, neutron shield density as part of the fabrication testing control process. The installation of the shielding materials should be performed with well documented quality assurance procedures. Further, users of the HI-STAR 180 implement should quality assured procedures to verify the integrity and effectiveness of Holtite-B neutron shield for each overpack. Finally, shielding effectiveness test should be performed for each of the package at the loading facility site to verify the effectiveness of the gamma and neutron shields using written and approved procedures.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.85(c).

8-7 Provide a revised Section 8.2.3.2 of the SAR that includes periodic shielding integrity and effectiveness tests in the Maintenance Program.

While the radiation survey specified in Chapter 7 of the SAR only ensures that the package meets 10 CFR Part 71 dose limits for a particular shipment. The periodic maintenance test should verify that the neutron shield performs as designed for any given contents and the verification should involve comparison of dose rate measurements for any given contents with values calculated for the same contents.

This information is required to confirm that the maintenance program adequately assures the package effectiveness throughout the service life of the package and to ensure compliance with 10 CFR Part 71 Subpart E.

8-8 Provide a discussion of the method(s) used to measure the areal density of the Metamic HT neutron absorber. Specify the neutron beam sized to be employed for the attenuation tests. If chemical tests are employed to measure areal density, discuss their correlation with other measurement methods.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5)(ii).

8-9 Provide a discussion of the protocol for acceptance test sampling of neutron absorber production lots. The discussion should also include details of the protocol for coupons or samples with yield values below the minimum required areal density. For example, the numbers of samples to be taken should be specified. Finally, the provision provided in the last paragraph of the referenced report on Metamic LLC that "if coupons from a lot were to exhibit an anomalous critical characteristic, then the entire lot will be discarded." This statement should be expanded and clarified so that the protocol for sampling and rejection of the lot are more clearly delineated.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5)(ii).

8-10 Provide a revised Section 8.1.5.4 of the SAR that includes a reference to each Metamic procedure that are regarded to be critical to safety.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(a)(5)(ii).