Request for Additional Information
Holtec International
Docket No. 71-9325
HI-STAR 180 Transportation Package

By letter dated January 17, 2009, Holtec International (Holtec) submitted an application for a Certificate of Compliance for the Model No. HI-STAR 180 Type B (U) Transportation Package. On February 19, 2009, Holtec submitted a supplement to the application to provide clarifications necessary to address concerns first raised during the January 21, 2009, pre-application meeting and further discussed in a second meeting on February 11, 2009.

This Request for Additional Information (RAI) identifies information needed by the U.S. Nuclear Regulatory Commission staff (the staff) in connection with its review of the HI-STAR 180 package application to confirm whether the applicant has demonstrated compliance with regulatory requirements. The requested information is listed by chapter number and title in the package application. NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," was used for this review.

Chapter 1 – General Information

1-1 Clarify the following sentence on page 1.0-1 of the application, "The enhanced protection against release of radionuclides that would be provided by an Enclosure Vessel is restored in the HI-STAR 180 cask by the use of two closure lids, where either closure lid is individually designated as a containment boundary component." The sentence should read "… where both closure lids are designated as containment boundary components." as defined in Chapter 4 of the application.

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

1-2 Clarify whether or not the pressures listed in Table 1.2.2 are in psia or psig units, as in Table 1.2.1.

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

Chapter 2 – Structural Evaluation

2-1 Justify the absence of the Classical Dynamics evaluation for predicting peak decelerations.

Due to the fact that no direct physical testing was to occur for the HI-STAR 180, the staff had previously indicated to the applicant that utilizing the Classical Dynamics Method previously approved for the HI-STAR 100 in conjunction with the use of LS-DYNA computational modeling would provide the reasonable assurance that the package would function as intended.

The staff verbally engaged the applicant regarding this issue. The staff was informed that the impact limiter for the HI-STAR 180 was significantly different from the HI-STAR 100 and HI-STAR 60 impact limiters and that such a comparison would therefore be invalid. Inspection of the design of the HI-STAR 60 impact limiter as well as the HI-STAR 180 impact limiter provided no discernable difference in the nature of the construction or load path that would preclude this methodology from being employed.

Additionally, the text of the HI-STAR 180 application states "The impact limiter configured on the above design platform is referred to as "AL-STAR" and is used in all models of HI-STAR transport packages, including the first package (HI-STAR 100), and subsequent packages labeled HI-STAR HB, HI-STAR 60, and this package (HI-STAR 180)."

This information is necessary to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

2-2 Revise the puncture evaluation to remove nonphysical deformation and unrealistic material failure.

A direct observation of the side drop puncture simulation shows that a portion of the 6 inch diameter mild steel puncture pin fractures and subsequently penetrates itself in a nonphysical manner. The fracture event is followed by the ejection of a fractured portion along the axis of the pin away from the simulated cylindrical package surface. This fracture produces an incorrect deformation pattern in the outer surface of the package which indicates that the puncture pin acts as a hollow cylinder, rather than a solid steel cylinder.

This information is necessary to determine compliance with 10 CFR 71.73(c)(3).

2-3 Clarify the value assumed for the dimension of the interstitial space between the single pin fuel model and the contact boundary which simulates a basket wall or adjacent fuel pin.

The degree to which the single fuel pin is allowed to displace laterally is a primary driver in the determination of the strain ductility demand of the cladding. The staff is unclear whether the applicant used the maximum in-plane dimension measured to the adjacent fuel pin or basket wall or whether the applicant used the maximum out of plane dimension (approximately 1.414 times greater) when determining the model dimensions.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-4 Explain the discrepancy between the peak G load when extracted from the monolithic shield cylinder versus the peak G load extracted from the containment shell.

An overlay plot of the filtered deceleration time histories of the monolithic shield cylinder and the containment shell showed that the containment shell peak deceleration was higher (~98Gs, filtered at 450Hz, 145.7 Gs unfiltered) than the reported value for the monolithic shield cylinder. The staff requests an explanation as to why the higher of the two peak G loads was not considered when setting the design basis G load for the bottom down end drop.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-5 Clarify the design criteria value of 0.5 mm for total allowable global average basket panel deformation.

The applicant defines a design limit for maximum fuel basket panel deformation of 0.5 mm. The staff is unclear whether this deformation limit is in addition to initial out-of-straightness of the basket panels, thickness tolerances and stackup of cell tolerances that exist in an as-built basket, or if this limit is inclusive of the other components that contribute to geometric irregularities.

Given that the FEA models do not take into account these geometric irregularities, staff is unclear as to the basis for setting such a strict criterion for deformation and whether these other effects have been considered when evaluating this package for criticality safety.
In addition, if such a strict criterion is necessary for structural performance, the staff is unclear as to why the other geometric irregularities are not considered given the likelihood that they will be within an order of magnitude of the acceptance criteria.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-6 Provide a comparison of the 0.5 mm global average basket panel deformation acceptance criteria as it relates to Subsection NG of the ASME code.

A comparison with existing standards would give reasonable assurance to the staff that the value of 0.5 mm global average deformation is appropriate, conservative, and achievable.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-7 Justify the use of ANSYS when determining the average global panel deformation for the side drop orientation while using LS-DYNA to evaluate panel deformation for the end drop orientations.

Table 2.7.6 indicates that the global average deformation for the side drop is less than 0.5 mm (no value is reported) yet the top end drop and bottom end drop results for the ANSYS evaluation state that the information is “Not Applicable.” Table 2.7.9 lists key performance objectives for non-containment components and it simply states that the global average fuel basket deformation is less than 0.5 mm. The staff assumes this table includes all orientations and therefore concludes that the applicant utilized the results from LS-DYNA to verify the deformations for the end drop cases.

The applicant has provided no benchmark results which would indicate that this approach is reasonable or conservative when evaluating deformation of the internal basket structure.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-8 Provide a sensitivity study showing that thick shell elements perform similarly to solid elements when predicting the structural performance of Metamic HT under axial and lateral dynamic (or quasi-static) loads.

The staff is unclear whether thick shell elements are appropriate given the geometry and loading conditions of the fuel basket.

The staff requests that a component evaluation be performed by the applicant, which demonstrates that the thick shell elements sufficiently predict stresses, strains, and gross deformation under dynamic and quasi-static loading, when compared with an equivalent geometric representation of a fuel basket containing appropriately discretized solid elements.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-9 Provide comparison tables in the application showing the relative component stresses, strains, or deformations as appropriate, obtained from the ANSYS static simulations and the LS-DYNA dynamic simulations.

This approach was discussed with the applicant and staff is requesting this information to be placed into the application for clarity and information purposes only. It allows for added reasonable assurance that the two finite element analysis approaches are producing reasonably consistent results.

This information is necessary to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

2-10 Clarify whether design internal pressure was included or was intended to be included in the pressure values calculated for the 9 meter hypothetical accident condition drops.

Given that the safety factors reported for the inner and outer lid bolts are relatively low when compared with the safety factors for other components that derive the containment boundary, staff requests that design internal pressure be explicitly considered in the HAC evaluation.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-11 Provide a rationale which illustrates why the 9 meter side drop deceleration time history is not influenced by FSL failure as was indicated in the HI-STAR 60 evaluation.

The deceleration time history for the HI-STAR 60 9 meter side drop showed a significant spike during the beginning of the deceleration time history which was subsequently reported as the governing peak value for the side drop. This same deceleration spike did not occur for the HI-STAR 180 side drop despite apparent design and load path similarities and staff is requesting an explanation for this discrepancy.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-12 Justify the use of a limiting G load of 60 Gs when evaluating fuel performance during the 9 meter bottom down fuel drop.

The top down end drop fuel analysis used a peak G load of 68.25 Gs as reported in the package application to assign a constant force value to the cask-ground spring (impact limiter). The bottom down peak G load is reported as 85Gs (filtered) on the monolithic shield in the application (97 Gs filtered, on the containment shell), yet the limiting G load value for this orientation is chosen as 60 Gs.

It is unclear to the staff why the approach for the two orientations is inconsistent. If the applicant is taking credit for the fuel impact attenuator (FIA) when assigning the constant force value cask-ground spring for the bottom down drop, the staff requests a thorough explanation of the methodology and reasoning employed by the applicant to arrive at the limiting value of 60 Gs.

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

2-13 Revise Section 2.3.2, “Examinations,” to be consistent with the format and content contained in the HI-STAR 60 application Rev. 2.

The current information presented in the HI-STAR 180 application is vague and incomplete. Provide content and format that is consistent with the detailed discussion which was prepared for the HI-STAR 60 application Rev. 2.

This information is necessary to determine compliance with 10 CFR 71.31(c).

2-14 Clarify whether or not the fuel basket design employs a strain control approach as opposed to the ASME Code Subsection NG stress limit approach.

The staff recognizes that Code Subsection NG is not invoked for the basket design.

This information is necessary for compliance with 10 CFR 71.43(f).

2-15 In Sections 2.6.1.4.2 and 2.7.8 of the application, provide an analysis for the vent and drain port cover bolts to confirm that the seals do not unload during NCT and HAC.

In Sections 2.6.1.4.2 and 2.7.8 of the application, it is stated that closure lid seals do not unload or that both lids will continue to maintain a positive contact load at their interface with the flange, but there was no discussion of other containment boundary seals, such as the vent and drain port cover seals. The application should demonstrate that all containment boundary seals do not unload during NCT and HAC.

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

Chapter 3 - Thermal Evaluation

3-1 Provide all material properties used for the HI-STAR 180 package thermal evaluation.

Section 3.2.1 (Material Properties) of the application provides a list of the materials used in the HI-STAR 180 thermal evaluation but some material properties are either missing in the tables or are incomplete (for example, bottom Insulation, lead, air).

This information is needed to verify compliance with 10 CFR 71.31.

3-2 Verify that the thermal properties used to perform the thermal evaluation of the HI-STAR 180 package are consistent with the properties provided in the application.

Table 3.2.7 of the application provides the material density and specific heat. The reported values for Metamic-HT and Holtite-B are different from the values used in the Fluent CFD case files.

This information is needed to verify compliance with 10 CFR 71.31.

3-3 Provide a detailed calculation of the Time-To-Boil limits presented in Table 3.3.5 of the application.

Section 3.3.3 of the application describes a method used by the applicant to obtain these limits. The method considers the rate of temperature rise of the cask as an adiabatic heat up process based on a lumped parameter equation. The described method assumes the components of the cask heat up at the same rate. This approach could underestimate the heat up of the water since it is in direct contact to the heat source (spent fuel).

This information is needed to verify compliance with 10 CFR 71.33.

3-4 Revise the Fluent CFD developed model for normal conditions of transport and for hypothetical accident conditions to include a gap between the panel thickness and the notch width of the intersecting panel of 0.8 mm.

The applicant's Fluent model includes this gap but a thickness of 0.4 mm is used instead of the 0.8 mm gap shown on the design drawings of the application.

This information is needed to verify compliance with 10 CFR 71.33.

3-5 Revise the Fluent CFD developed model for normal conditions of transport and hypothetical accident conditions to include a gap of 2 mm between any two stacked Metamic panels.

Note 8 of the HI-STAR 180 design drawings states that a gap between two stacked panels should not exceed 2 mm but the Fluent model does not include this gap.

This information is needed to verify compliance with 10 CFR 71.33.

3-6 Perform a fire and post-fire analysis of the HI-STAR 180 package using an emissivity of 0.8 or greater for all surfaces exposed to the fire.

The applicant's Fluent model includes fire exposed surfaces with emissivities less than 0.8. 10 CFR 71.73 specifies that all surfaces exposed to the fire shall have an emissivity greater than or equal to 0.8.

This information is needed to verify compliance with 10 CFR 71.73.

3-7 Calculate the maximum normal operating pressure (MNOP) for the HI-STAR 180 package inter-lid space.

Section 2.6.1.4.2 (Result Summary for Normal Heat Conditions for Transport) of the application states that the cask cavity and the inter-lid space MNOPs are below 5 psig but the application does not provide the calculated MNOP for the inter-lid space. Based on the applicant's analysis of the HI-STAR 180, the staff found that the MNOP for this region could be around 6.8 psig using the inter-lid reference bulk temperature and maximum gage pressure provided in Table 1.2.2 of the application and calculated the volume-averaged helium temperature from the applicant's Fluent thermal analysis model for normal conditions of transport. The above parameters are plugged in the combined gas law equation: $P_1V_1/T_1 = P_2V_2/T_2$. For the inter-lid space case, the above equation simplifies to $P_1/T_1=P_2/T_2$ (constant volume) with P_2 being the only unknown parameter.

This information is needed to verify compliance with 10 CFR 71.33.

3-8 Revise Tables 3.1.1 and 3.1.3 of the application to include the following containment boundary seals:

1. inner closure lid inter-seal test port plug seal,
2. inner closure lid port cover outer seal,
3. inner closure lid port cover test port plug seal, and
4. outer closure lid access port plug seal.

The seals listed above are part of the containment boundary, but the maximum temperatures were not included in Tables 3.1.1 and 3.1.3 of the application. The staff needs to ensure that the containment seal temperatures are below their specified limits.

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

Chapter 4 – Containment Evaluation

4-1 Describe how the outer seals of the inner lid, and vent and drain ports are being tested with the inter-seal test ports given the helium environments are inside the cask and below the port covers. Also see RAI 7-4 below.

It is not clear to the staff how the outer seals of the inner lid and vent and drain ports will be tested using the inter-seal test port plug considering that the helium environments are inside the cask and below the port covers. If the user will be using the inter-seal test ports to test the outer seals as described in Section 4.1.3.1.1 of the application, it appears that the application is relying upon the inner seals of the inner lid and vent and drain ports to provide the containment function.

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

4-2 Clarify the lack of stainless steel weld overlay provided during manufacturing for the vent and drain port covers and mating surfaces to protect the sealing surfaces against corrosion.

It is stated in Sections 4.1.3.1.1 and 4.1.3.1.2 of the application that stainless steel weld overlays are provided during manufacturing of the inner and outer closure lids to protect sealing surfaces against corrosion. The staff would like clarification as to why stainless steel weld overlays are not used to protect other sealing surfaces such as the inner lid vent and drain port covers and their mating surfaces during the manufacturing process.

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

4-3 Describe maintenance and periodic leakage rate tests according to Sections 7.4 and 7.5 respectively of ANSI N14.5-1997 in Section 4.4 of the application. Also describe maintenance and periodic leakage rate tests in Section 8.2.2 and Table 8.1.2 of the application. Also clarify if leakage rate tests will be performed at the time of closure of the lids.

In Section 4.4 and in Table 8.1.2 of the application, fabrication leakage rate tests and pre-shipment leakage rate tests were described, but maintenance and periodic leakage rate tests were not included. According to ANSI N14.5-1997, the purpose of the maintenance leakage rate test is to confirm that any maintenance, repair, or replacement of components has not degraded the containment system, while the purpose of the periodic leakage rate test is to confirm that the containment capabilities of the packagings built to an approved design have not deteriorated during a period of use.

Maintenance leakage rate testing shall be performed prior to returning a package to service following maintenance, repair (such as a weld repair), or replacement of components of a containment system. Periodic leakage rate testing shall be performed within 12 months prior to each shipment and shall be performed for all containment boundary seals and closures. Maintenance and periodic leakage rate tests should also be described in Section 8.2.2 of the application.

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

Chapter 5 – Shielding Evaluation

5-1 Justify the use of SAS2H/ORIGEN-S codes with the 44groupndf5 cross section library in performing source term calculations for UO_2 assemblies up to a maximum burnup of 66 GWd/MTU and for MOX assemblies up to a maximum burnup of 61.5 GWd/MTU.

Point depletion codes, such as SAS2H/ORIGEN-S have been validated for PWR fuel with a maximum burnup significantly less than the burnups requested in this application (ref. NUREG/CR-6701, Review of Technical Issues Related to Predicting Isotopic Compositions and Source Terms for High-Burnup Fuel).

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 necessary to ensure compliance with 10 CFR 71.47 and 71.51.

Chapter 6 – Criticality Evaluation

6-1 Revise the criticality analysis results to include the reactivity effect of potential gaps in the neutron absorber panel walls.

The 0.0010 change in k_{eff} due to modeling these gaps is larger than the standard deviation of the calculations. Subsequent models in the criticality analysis should either include the gaps, or the effect of the gaps should be included in any reported k_{eff} results.

This information is needed to ensure that the package is subcritical considering the most reactive credible configuration consistent with the chemical and physical form of the material in the package, per 10 CFR 71.55.

6-2 Provide a reference for the HI-STAR 100 analysis demonstrating that the fraction of ^{10}B lost during the service life of the fixed neutron absorber by neutron absorption is negligible.

Section 6.3.2 of the application refers to a MCNP4a calculation performed for a previously approved version of the HI-STAR 100 transportation package, but does not provide a specific reference for this calculation.

This information is needed to ensure that the package is subcritical considering the most reactive credible configuration consistent with the chemical and physical form of the material in the package, per 10 CFR 71.55.

6-3 Refer to proprietary enclosure.

6-4 Refer to proprietary enclosure.

6-5 Refer to proprietary enclosure.

6-6 Refer to proprietary enclosure.

6-7 Refer to proprietary enclosure.

Chapter 7 – Package Operations

7-1 Provide a cautionary note in Section 7.2.2 of the application to ensure that the fuel is protected by an inert gas during fuel unloading.

Section 7.1.2.1 of the application provides a caution about ensuring that an inert gas protects the fuel during loading operations. However a similar caution appears to be missing from Section 7.2.2, which discusses fuel unloading.

This information is necessary for compliance with 10 CFR 71.43(f).

7-2 Revise the package loading procedures in Section 7.1.2.1 of the application to include steps related to the verification of assembly burnup, as described in Appendix 6.F of the application.

Step 2 of the Fuel Loading Operations in Section 7.1.2.1 of the application includes requirements for verifying that the fuel to be loaded meets the conditions of the Certificate of Compliance (CoC), as well as for visual verification of the assembly identification. This section does not include the steps outlined in Appendix 6.F of the application, related to alternatives for the verification of assembly burnup. This section of the operating procedures should be revised to include these steps, or to refer the package user to Appendix 6.F for the assembly burnup verification procedure.

This information is needed to ensure that the package will remain subcritical per the criticality safety requirements of 10 CFR 71.55 and 71.59, when used in accordance with operating procedures for the package in Chapter 7 of the application.

7-3 Describe how vacuum drying or helium forced dehydration will thoroughly dry the wetted containment boundary items and seal grooves.

Because it is stated in Section 7.1.2.1.3 of the application that the sealing surfaces will be underwater, the application needs to demonstrate that the wetted containment boundary items and seal grooves will be dried to assure performance of the seals.

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

7-4 Revise Chapter 7 of the application to describe how the helium leak tests are performed so that the tests effectively detect potential leakage. Specifically describe what spaces are being evacuated during the helium leak test.

Table 1.2.1 of the application is referenced in Chapter 7 to describe the helium backfill pressure requirements for the cask cavity. The pressures listed in Table 1.2.1 are below atmospheric; therefore there is no driving force for the helium during helium leak testing because an evacuated envelope has not been described. The evacuated envelope should be described for all helium leak tests.

In Section 7.1.2.1.12 of the application, the containment boundary outer seal of the inner closure lid and outer seals of the inner lid two port covers are helium leak tested. Yet the helium is in the space beneath the port covers and inside the cask cavity. In these situations, because the containment boundary outer seal and the helium is separated by the inner seal, the leakage tests described in Section 7.1.2.1.12 of the application would be relying on the inner seal to also prevent leakage during testing. In order to ensure effective helium leak tests, the interseal pressure should be greater than the cask pressure or pressure in the space beneath the port covers.

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

7-5 Revise Sections 7.1.2.1.12 and 7.1.2.1.13 of the application to specify the purity and pressure requirements of helium used for helium leak testing.

The application should specify the purity and pressure of helium that will be used to assure any leakage would be identified during helium leak testing.

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

Chapter 8 – Acceptance Tests and Maintenance Program

8-1 Include in Section 8.1.3.2 (Pressure Testing) of the application a requirement for pressure testing of the HI-STAR 180 inter-lid space.

Section 8.1.3.2 of the application states that pressure testing of the HI-STAR 180 containment boundary is not required (the cask cavity and the inter-lid space MNOPs in Table 2.1.1 are below 5 psig; therefore, the provision of 10 CFR 71.85(b) does not apply.

However, based on the staff's calculation (see RAI 3-7), it appears the MNOP inter-lid space is above 5 psig which would require pressure testing of the containment system.

This information is needed to verify compliance with 10 CFR 71.85(b).

8-2 Provide the sampling plan of page 8.1-11 of the application, Table 8.1.3, Note 2, Reference 1.2.25.

This information is necessary for compliance with 10 CFR 71.43(f).

8-3 Modify Section 8.1.4 of the application to ensure that cask containment boundary leakage testing shall be performed in accordance with the requirements of ANSI N14.5-1997.

The staff has accepted ANSI N14.5-1997 as the appropriate method for leak testing, unless justification for an alternate methodology is provided.

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

8-4 Include the following tasks in the "Maintenance Inspections and Tests Program Schedule," Table 8.2.1 of the application.

1. The seal replacement for inner closure lid inter-seal test port plug seal.
2. The bolt replacement for inner closure lid port cover bolts.
3. The seal replacement for inner closure lid port cover test port plug seal.

The items listed above are part of the containment boundary, but maintenance inspections were not included in Table 8.2.1 of the application. The staff needs to ensure that the containment components are maintained appropriately.

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

8-5 Modify Section 8.2.2 of the application to ensure that cask containment boundary leakage testing should be performed on all containment seals listed in Table 8.1.2 prior to transport if the pre-shipment leakage rate test expires.

The staff needs to ensure that leakage testing is performed on all containment boundary seals if the pre-shipment leakage rate test expires after one year.

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

Others

O.1 Clarify which references to information in Chapters 1 through 6 of the package application, and other supporting documents, are incorporated by reference into the CoC.

The application, in the proposed draft CoC, licensing drawings, and Chapters 7 and 8 of the package application, makes numerous references to critical characteristics or important to safety (ITS) engineering or design information and data in numerous locations in other chapters or supplemental documents such as the "Metamic HT

Qualification Sourcebook." Due to the nature of the information, much or all of it must be, and is thus assumed by the staff, to be incorporated by reference into the CoC. However, it is not clear if that is the applicant's intent in every case.

This information is required for compliance with 10 CFR 71.33 and 71.107.

O.2 Remove the reference to storage in paragraph 5(a)(2) of the CoC.

The staff understands that the design is eventually intended for dual use. However, the present licensing action is for transportation only. No suggestion of regulatory acceptability for spent fuel storage is appropriate at this time.

This change is necessary for compliance with 10 CFR Part 71.

Licensing Drawings

D.1 Show that the transition buttering welding method, without the Code specified PWHT, will provide adequate ductility in the weld zone between the shield cylinder and bottom ring forging.

Licensing Drawing No. 4845, sheet 2, note 40, specifies an alternative to the Code welding requirement. However, it is not clear what the material properties will be with this method, and whether the properties are considered in the structural model.

This information is necessary for compliance with 10 CFR 71.43(f).

D.2 Clarify the use of the phrase "non-Code weld," which appears on licensing drawing 4845, sheet 2, notes 10 and 44, and other places in the SAR.

The staff suggests terminology such as "non-ASME welds."   Such welds would invoke other codes. Some suitable alternative welding codes would be ANSI D1.1 and D1.6. The staff considers that if a weld is not important to safety, it may be noted as such, and further details omitted.

This information is necessary for compliance with 10 CFR 71.43(f).

D.3 Discuss the rationale for specifying an MGV for Metamic HT weld strength at the stated percentage of the base material strength, as noted on licensing drawing 4847, sheet 1, note 17, and Drawing No. 4848, sheet 1, note 17.

The staff understands there is a strength penalty when welding Metamic HT and observes that Code Subsection NG is not the design code. However, the MGV approach appears to be significantly different from the ASME Code Section II, Appendix 1, approach of establishing a stress allowable which is the lesser of 2/3 the minimum yield or 1/4 the minimum tensile (and minus the penalty factor for Metamic HT weld properties in this case). It appears that the Code approach provides a significantly greater margin of safety. Alternatives to the ASME Code are expected to provide an equivalent margin of safety.

This information is necessary for compliance with 10 CFR 71.43(f).

Drawings Material List

DM-1 Revise the primary function of the outer closure lid to be containment on the bill of materials.

On the bill of materials, for item number 25 the outer closure lid, the primary function is described as being structural when it is part of the containment boundary. The staff believes the primary function should be containment because the component is part of the containment boundary in Chapter 4 of the application.

This information is needed to determine compliance with 10 CFR 71.33(a)(4).

DM-2 Clarify the inconsistency in the containment system components between Chapter 4 of the application and the engineering drawings bill of materials.

Chapter 4 states that the containment system components includes the inner lid outer seal while the bill of materials states that the containment system components includes the inner lid inner seal.

This information is needed to determine compliance with 10 CFR 71.33(a)(4).

DM-3 Revise Drawing No. 4845-6 or the bill of materials to include the following:

a. Groove surface finish with maximum average surface roughness (e.g., RMS) for all of the seal grooves.

b. Groove and seal dimensions for the following containment boundary seals:

1. inner closure lid inter-seal test port plug seal,
2. inner closure lid port cover test port plug seal, and
3. outer closure lid access port plug seal.

c. A reference to Table 2.2.12 of the application.

The staff could not find the surface roughness listed on the drawings for the seal grooves. Also, the seals listed in Part b. are part of the containment boundary, but the groove and seal dimensions were not included on Drawing No. 4845-6. The staff needs to ensure dimensions and surface finish are provided for all seals and seal grooves as appropriate. Because Table 2.2.12 in the application includes critical characteristics of the seals, it should be referenced in the bill of materials.

This information is needed to determine compliance with 10 CFR 71.33(a)(4).

DM-4 Clarify how the size of the seal in relation to the size of the groove was determined.

Section 2.2.1.1.6 of the application states that the size of the seal in relation to the size of the groove is a critical dimension.

This information is needed to determine compliance with 10 CFR 71.33(a)(4).

Metamic HT Qualification Sourcebook

M.1 Provide and defend the rationale for using two standard deviations below the mean for establishing minimum guaranteed values for Metamic HT versus the ASME Code method of Sec. II, Appendix 1. This appendix specifies using, among several other limits, the lesser of 2/3 the minimum yield or 1/4 the minimum tensile for setting maximum allowable stress.

The staff appreciates that ASME Subsection NG is not invoked as the design code for the basket. However, it appears that the Code approach provides a significantly greater margin of safety with respect to material properties. Alternatives to the ASME Code are expected to be fully explained and to provide an equivalent margin of safety.

This information is necessary for compliance with 10 CFR 71.43(f).

M.2 Refer to proprietary enclosure.

M.3 Refer to proprietary enclosure.

M.4 Describe the quality assurance measures used to ensure that the raw and averaged property data provided in the Metamic HT Sourcebook tables is accurate.

A simple evaluation of the reported mechanical property data largely validated the reported $\overline{X}$, σ , and P_{95} values. However, the reported $\overline{X}$, σ, and P_{95} values for the following properties are erroneous (at least based on the raw data in the report):

a. σ_{ult} of the as-extruded data at 20C (P_{95} values higher than reported) and 350C (P_{95} values lower than reported).
b. σ_{ult} of the aged data at 20C (P_{95} values higher than reported).
c. CVN of the as-extruded data at 200C (P_{95} values lower than reported).

While the differences between the reported and actual values are not terribly large, it raises questions about the general accuracy of the information provided in the tables.

This information is necessary for compliance with 10 CFR 71.43(f).

M.5 Identify and describe all of the MGV uses. For each unique MGV application (i.e., quality control or design calculation), justify how the use of the MGV is appropriate, representative, or conservative, as applicable.

This information is necessary for compliance with 10 CFR 71.43(f).

M.6 Discuss whether certain MGV values, such as Youngs modulus and coefficient of thermal expansion, should be restated as mean values rather than guaranteed minimums.

Some design characteristics are more conservatively served by using mean property values instead of minimums. However, the property data for Metamic HT is presented in terms of MGV for all properties.

This information is necessary for compliance with 10 CFR 71.43(f).

M.7 Provide details of the Metamic HT production sampling plan along with a justification of how the sampling plan ensures that acceptable material properties will be developed and maintained during production.

The application mentioned that the sampling plan is based on Mil Standard 105E, but without additional justification, the staff does not consider this sufficient to evaluate the appropriateness of any plan.

This information is necessary for compliance with 10 CFR 71.43(f).

M.8 Identify the separate production lots associated with each mechanical property and thermal test coupon. Quantify the lot-to-lot variability for the material.

The Metamic HT Sourcebook does not indicate the relationship between the coupons and the lots. It is not clear how many coupons were obtained from each lot, or how many lots were evaluated as part of this testing. This is an important consideration because it addresses lot-to-lot variability in properties. Lot-to-lot variability is important from both a quality assurance standard and a performance standpoint.

This information is necessary for compliance with 10 CFR 71.43(f).

M.9 Refer to proprietary enclosure.

M.10 Refer to proprietary enclosure.

M.11 Describe the experimental approach and the analysis used to calculate ρ (density). Also, justify why one test sample at each temperature is sufficient to represent the ρ from production heats of materials, or alternatively conduct more testing to quantify lot-to-lot variability.

Density values are reported in Table 6.3 as a function of temperature, but the report provides little information on how these values were obtained. The report only indicates that "… density was calculated using the thermal expansion of the LVDT." This statement is unclear and the report does not use multiple tests at each temperature to characterize material variability. Understanding the variability with temperature may be important if ρ is important for design. The discussion should identify all applicable testing and/or analysis standard(s) that were followed, and quantify the uncertainties in the calculated values resulting from the approach and analysis.

This information is necessary for compliance with 10 CFR 71.43(f).

M.12 Refer to proprietary enclosure.

M.13 Provide the k, C_p, and ρ values used in calculating thermal diffusivity at each temperature in Table 6.3 and describe how the k, C_p, and ρ values were derived from the information reported in Tables 6.1, 6.2, and 6.3, respectively, for each value

The report indicates that the thermal diffusivity (a) values were calculated as a function of temperature using the values for k, C_p, and ρ. However, it is not clear what particular values were used. The staff was unsuccessful in replicating the report thermal diffusivity results using reported values for k, C_p, and ρ.

This information is necessary for compliance with 10 CFR 71.43(f).

M.14 Demonstrate that the reported coefficient of thermal expansion (CTE) values are appropriate for use in the Hi-Star application given that this application is limited to lower temperatures than the test measurement range. Additionally, discuss variability in the CTE associated with both specimen-to-specimen and lot-to-lot differences.

The CTE was determined over a temperature range of 80 to 1000ºF (26ºC to 537ºC) using only two test specimens. However, the report indicates that the maximum temperature for the HI-STAR application is limited to 350ºC. The CTE for materials varies with temperature and the measurements result in an average value over the temperature range tested. Therefore, it is unclear if the reported CTE values are representative or conservative over the smaller temperature range expected in service. Further, it is not clear if two specimens are sufficient to capture lot-to-lot or even specimen-to-specimen variability.

This information is necessary for compliance with 10 CFR 71.43(f).

M.15 Provide the details associated with the calculations of the thermal diffusivity and CTE values.

The Metamic HT Qualification Sourcebook indicates that the rule of mixtures was used to independently corroborate the thermal diffusivity and CTE values. Details should describe the calculation approach, assumptions, the input values, and variability in the results associated with uncertainties in the approach, assumptions, and input values. Details should also discuss limitations in the applicability of this procedure to actual materials.

This information is necessary for compliance with 10 CFR 71.43(f).

M.16 Describe the experimental approach used to measure the emissivity (ε) and describe how it meets or deviates from any other testing standards or approaches that are commonly used to measure ε. Quantify the variability in ε due to specimen-to-specimen and lot-to-lot variability, or justify why the reported values appropriately account for this variability. Identify the intended use of the correlation expression for ε. If it is intended to be used in design or quality assurance, provide the basis for this correlation and demonstrate why the expression conservatively bounds ε in light of uncertainties associated with the reported values.

The emissivity values are presented as a function of temperature in Table 6.5. The text indicates that three test coupons were sent to GeoScience Ltd., for analysis and that the "… 'infrared emissivity heated cup measurement technique' which is approved by NASA Ames Research Center and other government agencies…" was used. The report further provides a correlation expression of ε as a function of temperature. This expression does bound the data in Table 6.5 (i.e., the calculated values are below the values reported in the table).

There are several issues related to these measurements. First, the measurement technique is neither referenced nor described, nor is the approval of this method by NASA Ames documented. Second, only single ε values are provided at each temperature. It is not clear if multiple measurements were made at each temperature and the expected measurement uncertainty is not described. As with other properties, variations in emissivity from specimen-to-specimen and lot-to-lot are also not quantified. Finally, the report does not provide a basis for the correlation nor justify why the expression is expected to remain conservative in light of variability in the measured data.

This information is necessary for compliance with 10 CFR 71.43(f).

EDITORIAL

E.1 Remove the reference to MGDS on page G 5 of the Glossary. The Mined Geologic Disposal System has no bearing on the HI-STAR 180 application.

E.2 Delete or explain the reference to 10 CFR 71.43(g) in the first paragraph of Section 1.1 "Introduction" of the application.

E.3 Correct tense on page 1.1.2 of the application "Although the safety analyses is not.." or replace analyses by analysis. Replace "neuron" by "neutron" on page 2.1-16 of the application. Replace "expect for" by "except for" on page 2.6-8.

E.4 Clarify data from Section 1.2.1.2 and Table 2.2.11 of the application which apparently shows that a loaded HI-STAR 180 appear to weigh less than a nominal empty packaging with either the F-32 basket or the F-37 basket.

E.5 Correct the temperature for loading patterns A, B for the F-37 fuel basket in Table 3.3.4. This table still shows a higher peak cladding temperature than in the original bounding case. Replace 303ºC by 309ºC as previously indicated and evaluate additional corrections.

E.6 Explain the meaning of the first paragraph of Section 2.2.1.1.6 and in particular of the reference to "2.7.7, page 86."