**Request for Additional Information**
**for the**
**Model No. 2000 Package**
**Docket No. 71-9228**

By application dated December 12, 2014, General Electric-Hitachi (GEH) submitted a special authorization request for Certificate of Compliance (CoC) No. 9228 for the Model No. 2000 package. The request is for use of a new internal configuration for limited shipments of Co-60 which exceed the amount allowed in the CoC for the currently approved design.

This request for additional information (RAI) identifies information needed by the staff in connection with its review of the application. The requested information is listed by chapter number and title in the applicant's safety analysis report. The staff reviewed the application using the guidance in NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

## Chapter 2 – Structural/Materials

2.1 Clarify the application statement, "[T]he material Basket has [[Withheld pursuant to 10 CFR 2.390]] locations that are formed by [[Withheld pursuant to 10 CFR 2.390]]" to ensure it is consistent with those depicted in Drawing No. 001N8424.

In Section 1.2.2.2, "HPI Material Basket", the drawing seems to show only [[Withheld pursuant to 10 CFR 2.390]] locations for loading [[Withheld pursuant to 10 CFR 2.390]]. Also, the [[Withheld pursuant to 10 CFR 2.390]] are shown to be fabricated with [[Withheld pursuant to 10 CFR 2.390]] in Drawing No. 001N8424.

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

2.2 Justify the uniform equivalent static pressure assumption, along the High Performance Insert (HPI) axis, to represent the inertia load produced by the loaded Material Basket in determining margins of safety. If a line load assumption is considered, identify the stress acceptance criteria and corresponding margins of safety for the inner shell of the HPI subject to the normal conditions of transport (NCT) side-drop tests and conditions.

Regarding Section 2.6.7.5, Boundary Conditions, Drawing No. 001N8424 shows that the Material Basket is laterally supported by [[Withheld pursuant to 10 CFR 2.390]]. As such, contrary to the "area load" distribution assumption, the HPI inner shell is expected to be subject to a "line load" at each of the [[Withheld pursuant to 10 CFR 2.390]] locations.

This information is needed to determine compliance with 10 CFR 71.33(a) and 71.71(c)(7).

2.3 For the boundary conditions discussed above, if a line load assumption is to result, identify also in Section 2.1.2, Design Criteria, the stress acceptance criteria and corresponding margins of safety for the inner shell of the HPI subject to the NCT side-drop tests and conditions.

In Section 2.1.2, Design Criteria, the peak stress intensities displayed in the figures are all shown to be much larger than the reported maximum stress intensities listed in Table 2-15. It's unclear the basis for reporting the markedly lower stress intensity values in the table.

This information is needed to determine compliance with 10 CFR 71.33(a) and 71.71(c)(7).

2.4 In Figures 2-10, -11, -12 and -13, HPI NCT Side Drop Results, regarding Peak Stress Intensity, clarify how the "peak stress intensities," shown as stress fringe plots in the figures, are calculated then post-processed for the primary membrane and the primary membrane-plus-bending stresses summarized in Table 2-15 of the application.

The peak stress intensities displayed in the figures are all shown to be much larger than the reported maximum stress intensities listed in Table 2-15. It's unclear what the basis is for reporting the markedly lower stress intensity values in the table than those shown in the stress fringe plots in the figures.

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

2.5 Revise the Material Basket side-drop evaluation to recognize that: (a) there is [[Withheld pursuant to 10 CFR 2.390]] design feature described for the [[Withheld pursuant to 10 CFR 2.390]] to develop composite action, thus enabling the use of the area moment of inertia, Ix, to calculate the extreme fiber stress in the outer most [[Withheld pursuant to 10 CFR 2.390]], and (b) the [[Withheld pursuant to 10 CFR 2.390]] in contact with the [[Withheld pursuant to 10 CFR 2.390]] are each subject to a concentrated inertia load at the [[Withheld pursuant to 10 CFR 2.390]] location. As such, [[Withheld pursuant to 10 CFR 2.390]] wall permanent deformations are likely to occur and the Subsection NF, Level A stress acceptance criteria, will cease to apply.

In Section 2.6.7.8, "Material Basket Evaluation," the potential for a deformed [[Withheld pursuant to 10 CFR 2.390]] after the NCT free drop must be evaluated as an analyzed configuration.

This information is needed to determine compliance with 71.71(c)(7).

2.6 Explain in detail the fabrication sequence of the HPI assembly components containing depleted uranium (DU) shielding material.

Describe the [[Withheld pursuant to 10 CFR 2.390]] utilized how contamination from capillary attraction, at the root layer will be avoided of melted DU.

HPI assembly licensing Drawing No. 001N8423 section A-A shows the various components, [[Withheld pursuant to 10 CFR 2.390]], containing DU material. No backing material or note to remove material in way of closure welds or gaps are identified on any of the various detailed drawings. The staff is concerned with the integrity of the welds without precautions identified to preclude contamination/oxidation.

This information is needed to ensure compliance with 10 CFR 71.33(a)(5)(iii).

2.7 Provide American Society for Testing & Materials (ASTM) or American Society of

Mechanical Engineers (ASME) or other consensus standards for all materials identified on all HPI drawings or explain why commercial specification designations are acceptable for use in fabricating the HPI and explain the use of "or equivalent" .

HPI assembly license drawing 001N8423 and drawing parts lists (001N8423G001, 001N8422G001, 001N8427G001, do not provide ASTM/ASME specifications for all materials identified for use in fabrication of the HPI assembly. In addition, "commercial" specification and "or equivalent" is used in identifying material and/or specifications. The staff needs specifications to verify chemistry, mechanical properties and various other necessary details of material fabrication for the HPI assembly.

This information is needed to ensure compliance with 10 CFR 71.33(a)(5)(iii).

2.8 Explain the use of the weld symbols.

The staff is unfamiliar with the weld symbol indicated on drawing 001N8425 sheet 1of1, Detail C, Item 1 to 8 and Detail D [[Withheld pursuant to 10 CFR 2.390]] when utilizing the American Welding Society (AWS) A2.4, Standard Symbols for Welding. Define whether these weld symbols are square or bevel.

This information is needed to ensure compliance with 10 CFR 71.33(a)(5)(iii).

**Chapter 3 – Thermal**

3.1 Provide the maximum temperatures of the O-rings located at test port, vent port and drain port, separately, under NCT and hypothetical accident conditions (HAC).

As stated in SAR 1.2.1.1, GEH-2000 package has O-rings (made of [[Withheld pursuant to 10 CFR 2.390]]) installed at the test port, vent port, and drain port. Instead of listing one "single" maximum temperature of cask seal in SAR Table 3-4 for HAC and Table 3-12 for NCT, the applicant needs to provide the maximum temperatures of the O-rings located at test port, vent port and drain port, separately. This information is necessary to confirm that the temperatures are in fact below their design limits under NCT and HAC

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

3.2 Perform the thermal analysis using an average emissivity coefficient of at least 0.9 for the HAC 30-minute fire.

The applicant stated in SAR Section 3.4 that thermal radiation exchange is between the fire (emissivity 0.9) and the package external surfaces (emissivity 0.8). The applicant noted in the RSI response that an emissivity of 0.7347 was calculated by using the equation for diffuse, gray, two-surface enclosure for infinite parallel plates and was then used in the ANSYS thermal analysis for the HAC 30-minute fire. The staff points out that for HAC 30-minute fire, the radiation feature between package surface and flame is different from the radiation feature between two "parallel" plates.

Given the fact that only one emissivity value "ε" was used as input into the ANSYS code for radiation heat transfer between the fire and the package surface, the applicant should use an average emissivity coefficient of at least 0.9 in the HAC 30-minute fire and an

average emissivity coefficient of less than 0.8 in the post-fire cooldown.

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

3.3 Revise the thermal analysis to use the forced convection coefficients between the fire and the package surface in the HAC 30-minute fire.

In SAR Section 3.4, under subsection 30-minute fire (transient analysis), the applicant assumed natural convection from the package external surfaces to the 100°F environment and used the calculated "natural" convection coefficients, displayed in SAR Figure 3-16, for the thermal analysis of the HAC 30-minute fire. With the fire temperature up to 1475°F (800°C), and the air under high fluctuation, the heat transfer from the fire to the package surface is in the mode of forced convection (not natural convection in the still air). Therefore, the applicant should revise the analysis with the forced convection coefficients used in the HAC 30-minute fire.

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

3.4 Explain the heat transfer features on the overpack outer shell and the package shell, as well as the temperature variation inconsistencies between the two, during the HAC 30-minute fire.

The applicant stated in SAR Section 3.4.1 that the drop onto the pin causes the overpack outer and inner shells to come in contact, thus creating a path for the heat from the fire to more easily reach the package shielding.

In SAR Table 3-13 and Figure 3-18, it is identified that the overpack outer shell has a lower temperature at the site with puncture-damage than the site opposite from puncture damage, but the package shell has a higher temperature at the site with puncture-damage than the site opposite from puncture damage, during HAC 30-minute fire. Therefore the applicant should address in detail the heat transfer features on the overpack outer shell and the package shell and explain the inconsistency in the temperature features between the overpack outer shell and the package shell, during the HAC 30-minute fire.

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

3.5 Provide information of the personnel barrier to ensure that the airflow cooling during transport will not be blocked.

SAR Section 3.3.1 states that the overpack in the region of the bolting ring exceeds the allowable temperature of 185°F and therefore, a protective personnel barrier will be used to block access to the region when ready for transport, in compliance with 10 CFR 71.43(g).

The applicant should provide a more detailed discussion of the personnel barrier so that the staff can verify what it will encompass and that it will not affect the heat removal performance of the package

This information is needed to determine compliance with 10 CFR 71.71 and 71.43(g).

3.6 (1) Provide references 28, 31, and 32, listed in Table 3-8 of SAR Section 3.3 (and SAR Section 1.3.3), for typical thermal contact conductance values, and (2) perform the thermal tests to verify that the thermal contact resistance levels assigned to the model contact elements are acceptable for the thermal analysis

The applicant determined the thermal contact conductance (TCC) values based on the open literatures 28, 31, and 32, listed in Table 3-8 of SAR Section 3.3 (and SAR Section 1.3.3 References). The applicant should provide these references to support the TCC values used in the thermal analysis.

The applicant should also perform the thermal tests to verify that the thermal contact resistance levels assigned to the modeled contact elements, as shown in SAR Table 3-10, exactly represent the thermal contact conditions between the components and are acceptable for the thermal analysis. The test results should be addressed in SAR Chapter 8.

Otherwise, the applicant should apply the "perfect contact (TCC = 1000 Btu/hr-in$^2$-°F)" to the model contact elements in the thermal analysis.

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

3.7 Clarify the temperatures and use of insolation in the HAC fire model.

Explain whether the initial temperatures for HAC are obtained from the NCT analysis with solar heat included or from the NCT analysis without solar heat.

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

**Chapter 4 Containment Evaluation**

4.1 Provide the basis for the O-ring compression and O-ring groove dimensions in the drawings (i.e., from manufacturer data sheets).

a) The staff needs to verify the appropriateness of the seal for the containment system, therefore the basis for the O-ring compression and O-ring groove dimensions, such as from manufacturer data sheets, should be provided for the seals and the manufacturer and part number of the O-rings should be provided on the drawings.

b) The drawings should indicate both the dimensions and tolerances of the groove dimensions and the O-rings to ensure compression of the O-rings.

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

4.2 Identify seal and O-ring importance to safety category.

SAR Section 1.2.4 and 1.3.2 state that a new [[Withheld pursuant to 10 CFR 2.390]] seals and O-rings will be used for the package but the seals and O-rings are not identified in a parts list.

All seals and O-rings should be identified on a parts list and their importance to safety category should be specified per NUREG/CR-6407, “Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety.”

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

4.3 Provide Appendix 4.5.1 which was not in the application.

The applicant has noted Appendix 4.5.1 “Cask Penetration Leaktightness test procedure and results” on SAR page 4-2, but the section is empty. The applicant should provide this appendix for review.

This information is needed to determine compliance with 10 CFR 71.33, 71.43(f), and 71.51.

4.4 Provide the American Society for Nondestructive Testing (ASNT) certification level of the examiner for development and approval of helium leakage rate testing procedures considering that industry standards indicate that this should be performed by a Level III examiner.

The applicant described the leakages tests in SAR Section 7.1.3.3, for assembly verification leakage testing and 8.1.4 for acceptance leak tests and 8.2.2 for periodic and maintenance leak test, without identifying the ANST certification level of the examiner.

American National Standards Institute (ANSI)/ASNT CP-189-2006, “Standard for Qualification and Certification of Nondestructive Testing Personnel,” states that a nondestructive testing personnel Level III examiner has the qualifications to develop and approve written instructions for conducting the leak testing.

This information is needed to determine compliance with 10 CFR 71.43(f), 71.51, and 71.87.

4.5 Demonstrate that the [[Withheld pursuant to 10 CFR 2.390]] O-rings can maintain containment function, leak tight, in a -40°F cold environment under normal and hypothetical accident conditions.

The applicant stated in SAR Section 4.1.3, that a new [[Withheld pursuant to 10 CFR 2.390]] O-ring seal, made of [[Withheld pursuant to 10 CFR 2.390]], designed to operate at a low -15°F based on information from the [[Withheld pursuant to 10 CFR 2.390]], will be used in the package. The applicant noted that a performance test of this material at -40°F will be performed to demonstrate that the material maintains leaktightness under these temperature conditions. The safety basis of the seals must be justified in the application. In light of the design limits specified in the [[Withheld pursuant to 10 CFR 2.390]], the applicant should demonstrate that the [[Withheld pursuant to 10 CFR 2.390]] O-rings can maintain leaktightness in a -40F cold environment under normal and hypothetical accident conditions.

This information is required by the staff to determine compliance with 10 CFR 71.71 and

71.73.

4.6 Demonstrate that there will not be any chemical, galvanic, or other reactions with the new seal and O-ring material.

SAR Section 1.2.4 and 1.3.2 states that a new [[Withheld pursuant to 10 CFR 2.390]] cask seal and port O-ring is used in the package.

The application should address whether this new material will cause any chemical, galvanic or other reactions to occur between the seal and the packaging or its contents, and that the seal will not degrade due to irradiation.

This information is required by the staff to determine compliance with 10 CFR 71.33 and 71.43(d).

4.7 Clarify the extent to which the system is isolated during vacuum-drying processes described in SAR Section 7.1.3.1.

SAR Section 7.1.3.1 briefly describes the vacuum-drying process used if the cask was loaded under water. This description states that "the system shall be isolated." The staff needs to verify that the system reaches 1 torr pressure due to no liquid in the system instead of the vacuum pump pulling past a valve that isn't completely closed. Therefore, the applicant should provide additional clarification of the drying operation to assure that the pressure measurement is reliable (turning vacuum pump off, etc.).

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

4.8 Clarify the use of fabrication, maintenance, and periodic and pre-shipment leakage rate tests in SAR Chapter 7 and Chapter 8.

a) SAR Section 4.4 does not reference the ANSI N14.5 standard when discussing the fabrication, maintenance, periodic, and pre-shipment tests. It should be stated in SAR Chapter 7 and Chapter 8 that "the fabrication, maintenance, periodic, and pre-shipment tests are performed in accordance with ANSI N14.5".

b) The leakage tests described in Chapter 7 and Chapter 8 should be called out as "fabrication, maintenance, periodic, or pre-shipment" tests in reference to ANSI N14.5.

c) The appropriate leakage rate test and sensitivity criteria should be explicitly listed in SAR Chapter 7 and Chapter 8 for the fabrication, maintenance, periodic, and pre-shipment leakage tests per ANSI N14.5 standards.

This information is needed to determine compliance with 10 CFR 71.43(f) and 71.51.

4.9 Confirm the extent of the containment boundary for the fabrication helium leakage test.

The applicant does not reference ANSI N14.5 in SAR Section 8.1.4 and does not include welds, joints and base material in the leakage tests.

ANSI N14.5 indicates that the entire containment boundary, which includes welds, joints, base material, valves, etc., should be part of the fabrication helium leakage test. The extent of the containment boundary that is helium leak tested should be stated in SAR Section 8.1.4.

This information is needed to determine compliance with 10 CFR 71.43(f) and 71.51.

4.10 Clarify the seal replacement period discussed on SAR page 8-6.

SAR Section 8.2.2 indicates that the cask closure seal and vent and drain plugs will be leak checked after every 12 usages. The replacement period should reflect the 12 month period described in ANSI N14.5.

This information is needed to determine compliance with 10 CFR 71.43(f) and 71.51.

4.11 Clarify the content limits applicable to each seal material option.

SAR Sections 1.2.1 and 1.2.4 state that the cask has new cask seal and port O-ring "options." Additionally, SAR Drawings Nos. 105E9520 and 101E8718 call out two seal options with Option 1 being a "Gask-O-Seal Configuration Both Sides, Parker Compound" and Option 2 being a "[[Withheld pursuant to 10 CFR 2.390]]." SAR Section 2.1.1 states that "for content loads up to 3000 watts," the cask seal and O-rings have this new [[Withheld pursuant to 10 CFR 2.390]] material. It is not explicit what the content limit is for Option 1.

The applicant should explicitly state the content limits applicable to each option.

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

4.12 Clarify leaktightness criteria for containment boundary leak testing.

SAR Section 4.1.3 states that performance tests of the seals will be performed to demonstrate leaktightness but the leakage criteria are not specified. The applicant should clarify if this leaktightness refers to the definition from ANSI N14.5 and provide the leaktightness criteria.

This information is needed to determine compliance with 10 CFR 71.33, 71.43(f), and 71.51.

4.13 Specify the leakage rate criteria for routine maintenance leak testing.

SAR Section 8.2.2.1 states that the cask closure seal and vent and drain plugs are leak tested using an instrument calibrated to a sensitivity of $1x10^{-5}$ atm. $cm^3$/sec (He) and if leakage greater than $1x10^{-3}$ atm. $cm^3$/sec is detected, offending components will be repaired or replaced and retested. SAR Section 4.1.3 states that tests will be performed on seals to demonstrate leaktightness.

Routine maintenance leak test criteria should be consistent with "leaktightness" terminology used and match with ANSI N14.5 standards of $1x10^{-7}$ ref. $cm^3$/s.

This information is needed to determine compliance with 10 CFR 71.33, 71.43(f), and 71.51.

4.14 Justify that the thermal conductivity leakage test method procedure would provide a qualitative and integrated measurement to show that the leakage acceptance criteria are met.

SAR Sections 7.1.3.3 and 8.2.2.1 provide information on leakage tests using thermal conductivity sensing instruments. It appears that the leakage test method relies on a sniffer method, which is typically a qualitative technique. Therefore, this method is not appropriate for leak testing the entire containment boundary (welds, base material, seals, etc.) for leak tests which must meet a quantifiable allowable leak rate (as stated in SAR Section 7.1.3.3 and 8.2.2.1) around the test boundary.

This information is needed to determine compliance with 10 CFR 71.33, 71.43(f), and 71.51.

4.15 Justify that the scaled test method used for seal testing is acceptable.

Research has shown that “Scale-model testing is not a reliable or acceptable method for quantifying the leakage rate of a full scale package” as noted in NUREG-1609 “Standard Review Plan for Transportation Packages for Radioactive Material” Section 4.5.3.2. The staff needs to verify that the seal testing method used in SAR Section 8.1.5.2 is acceptable.

This information is needed to determine compliance with 10 CFR 71.43(f), 71.51, 71.71, and 71.73.

4.16 Provide information on permeation of the new [[Withheld pursuant to 10 CFR 2.390]] seal material.

a) Permeation is known to be an issue with some [[Withheld pursuant to 10 CFR 2.390]] seal materials. The staff needs to know if the new [[Withheld pursuant to 10 CFR 2.390]] seal material is permeable to helium.

b) Permeation can be a problem when a leakage test procedure is being used to demonstrate that the system is leaktight. The degree of permeation is affected by seal material, seal surface area, time and temperature. If the new [[Withheld pursuant to 10 CFR 2.390]] seal material is permeable to helium, the staff needs to determine if permeation will be accurately differentiated from leakage when leak testing the [[Withheld pursuant to 10 CFR 2.390]] seals with helium to leaktight criterion on a repeatable basis.

Revise SAR Section 4.1.3.1, “Seals and Welds,” of the application to include information on permeation related to the new [[Withheld pursuant to 10 CFR 2.390]] seal material.

This information is needed to determine compliance with 10 CFR 71.43(d), 71.51(a)(1), 71.85(a) and 71.87 (c).

4.17 Provide information on the mass spectrometer leak detector (MSLD) leakage test method and instruments being used.

SAR Sections 8.1.4, 8.1.5.2 and 8.2.2.2 reference leakage tests being performed with MSLD. The staff needs to verify that the test method and instrument are appropriate. Provide information on the MSLD leak test instrument being used (sniffer, evacuated envelope such as ANSI N14.5 test description A.5.5, etc.)

This information is needed to determine compliance with 10 CFR 71.33, 71.43(f), and 71.51.

4.18 Provide the acceptable leakage rate for seal testing.

SAR Section 8.1.5.2 describes seal leak testing based on ANSI N14.5. The staff needs to verify that the test method is appropriate; therefore the applicant should provide the acceptable leakage rate for the test based on ANSI N14.5.

This information is needed to determine compliance with 10 CFR 71.33, 71.43(f), and 71.51.