Robatel Technologies, LLC
RT-100 RAI Meeting
June 19, 2013

RAI Dated March 28, 2013
TAC No. L24686
Docket No. 71-9365

Agenda

- Introduction
- Opening statement
- Presentation
- RAI Schedule
- Closing

RT-100 Certification Process Overview

- Submitted CoC Application No. 9365 October 9, 2012 for Type B radioactive waste transport cask – RT-100
- Received NRC RAI request dated March 28, 2013
- 63 items to answer and/or clarify
- Met with NRC on April 17, 2013 for early review of several RAI comments
- Two meetings to review RT's interpretation and path forward for NRC RAI
  - June 18 – Materials & Structural
  - June 19 – Thermal, Containment & Shielding
  - Time permitting, review other RAI responses
- Proposed approach and strategy for resolution

RAI 3-1:

Explain why a constant solar insolation is not used in NCT and HAC analyses.

The applicant described the solar insolation modeling in Section 6.5 of Calc. No. RTL-001-CALC-TH-0201, converted insolation from 400 and 800 g-cal/cm^2 to 388 and 776 W/m^2, respectively, per a 12-hour time period for both curved and horizontal flat surfaces, and then simulated insolation with the periodic sin(t x π/12) function. However, the insolation with the periodic function sin(t x π/12) should be modified.

Instead of simulating the solar insolation as a periodic heat flux, the applicant should directly apply the constant insolation of 388 W/m^2 for the curved surface and 776 W/m^2 for the flat surface in the model (without the sin(t x π/12) function). Application of a constant insolation is a regulatory requirement.

RAI 3-1 Response

- Application of solar insolation as a sine function is a conservative assumption utilized by Robatel in previous cask designs
  - Application of the solar insolation maintains the total heat input over the 12-hour period at the same value as if the constant values were specified
  - However, the resulting maximum temperatures are higher due to the peak periods where the solar insolation values are 609 and 1219 W/m^2 at their maximums, rather than maximums of 388 and 776 W/m^2 for the constant values
- In order to simplify the analysis for NCT and HAC conditions, Calculation RTL-001-CALC-TH-0201 is revised to apply the 10 CFR 71.71 solar insolation values as constants rather than using the sine function
- Additionally, the analysis is performed as steady state, with the 12-hour values being applied over 24 hours for conservatism
  - This conservative value is applied for the normal hot with solar and for the HAC post-fire cooldown transient

RAI 3-2:

Correct the radiation emissivity of the stainless steel used in the post-fire cooldown and re-analyze the HAC fire accident.

Table 3.2-1 “Temperature-Independent Material Properties” shows that a radiation emissivity of 0.9 for the stainless steel 304 is used for both the fire transient and the post-fire cooldown. To evaluate the heat flux under the HAC fire, the applicant should use an emissivity of 0.9 or greater for a 30-minute fire transient and an emissivity of 0.8 or less for the post-fire cooldown (see March 6, 2012, Meeting Summary, included in Appendix 6 of the application, ADAMS Accession No.: ML12075A026).

RAI 3-2 Response

- The emissivity of the outer surface of the cask has been updated to utilize a value of 0.8 for the post-fire cooldown condition
- Temperature results from the cooldown transient will be reflected in updated figures and tables in Chapter 3 of the SAR and Calculation RTL-001-CALC-TH-0201

RAI 3-3:

Demonstrate that there is no phase change, melting, or auto-ignition of the contents under NCT and HAC.

The applicant predicted a maximum temperature of 265°C (or 509°F) for the inner shell of the package under HAC. The staff reviewed the model description and identified that the maximum inner shell temperature of 265°C (or 509°F) is used to represent the maximum "local" gas/content temperature. Therefore, the applicant needs to provide the melting points and the auto-ignition temperatures of the allowed contents to assure that the contents (e.g., resin, filter), allowed in the Model No. RT-100 package, will not auto-ignite, melt, or change phase at a temperature below 265°C (or 509°F) under NCT and HAC.

RAI 3-3 Response

- The revised thermal analysis of the package indicates that the maximum inner shell temperature is approximately 255°C and the average inner shell temperature is 110°C
  - Accident inner shell temperatures are higher than the normal condition steady state temperatures due to the additional heat input from the fire
  - Contents will be at or below these temperatures because the temperature gradient across the cask wall slopes downward from the outer surface to the inner shell
  - Temperatures calculated for the inner shell are conservative because no credit is taken for the ability of the contents to absorb some of the heat in the inner shell during the fire transient
  - The maximum inner shell temperature of 255°C occurs at a localized region of the inner shell resulting from the pin puncture and lasts for only a short period of time
- The contents of the cask will include secondary containers, resins and filters
  - Secondary containers are constructed of either carbon or stainless steel, or a thermoplastic such as polyethylene or polypropylene
  - Resins are made of thermoplastics such as polystyrene, or material such as inorganic carbon or zeolite
  - Filters may be constructed from thermoplastics such as nylon, polyester, or polypropylene, or paper

(continued on next page)

RAI 3-3 Response (cont)

- Acceptable temperature ranges for the contents:
  - Carbon and stainless steel materials are acceptable up to approximately 800°C
  - Thermoplastics begin to soften in the range from 100°C up to 250°C
    - Softening of these materials does not result in any off gassing or produce any chemical reactions with any other contents
    - The auto-ignition temperatures of these materials are above 300°C
  - Paper filter media has an auto-ignition temperature of at least 230°C
- Because the bulk temperature of the contents will be less than 110°C, no thermal issues regarding phase change or combustion will occur
- Section 3.2 of the SAR will be revised to provide additional information regarding the thermal properties of these materials

RAI 3-4:

Explain why the HAC fire analysis does not start with the results from the NCT steady-state analysis.

The applicant used the same approach and models from NCT to evaluate HAC, and identified a time within the total run period of the NCT normal hot case, at which the inner shell temperature reaches its maximum, to serve as the starting time for the HAC fire analysis.

The staff does not find this approach to be conservative. The time at which the inner shell temperature reaches its maximum may not be the instant that other important-to-safety components, e.g., lead shielding and O-ring seal, reach their maximums. Instead of identifying a time to start HAC analysis, the applicant should perform the steady state analysis of NCT and start the HAC fire analysis with the applicable steady-state results. This steady state analysis of NCT provides the most conservative evaluation for all components in the package.

RAI 3-4 Response

- The fire accident analysis has been revised to utilize a steady state pre-fire analysis for the NCT hot case with an ambient temperature of 38°C
- As a result, the temperatures of all cask components at the start of the fire are based on the steady state results

RAI 3-5:

Explain the temperature fluctuations of the components, shown in Figures 3.3.1.3-1, 3.4.2.2-3 and 3.4.2.2-6 of the application as well as in Figures 9, 29, 30, 32, 34, 44, 45, 47, 48, and 50 of the report RTL-001-CALC-TH-0201, under NCT and HAC.

The applicant analyzed the NCT and HAC thermal performance of the Model No. RT-100 package and predicted the components' temperatures which fluctuate with time under NCT and HAC. To clarify the uncertainties in the thermal model, and evaluate the thermal performance of the package, explain the phenomena which cause the temperature fluctuations for both NCT and HAC analyses.

RAI 3-5 Response

- The temperature fluctuations were the result of the transient application of the solar insolation that is required to be applied for a 12-hour period (out of every 24 hours) in accordance with 10 CFR 71.71(c)(1)
  - Because the insolation was applied in a transient fashion, the temperatures fluctuated upward during periods of solar insolation and downward when the solar insolation was not applied
- In order to simplify the thermal analysis presented in the SAR, the analytical method has been revised to apply the 12-hour solar insolation values as a constant for the NCT steady-state analysis and for the HAC post-fire cool-down transient
- The SAR and calculation figures will be updated to reflect the revised analysis

RAI 3-6:

Provide the maximum component temperatures in Table 3.1.3-2 of the application, separately, for the top lid impact fire accident and the sidewall impact fire accident.

The applicant listed the maximum temperatures of the outer shell, inner shell, inner shell average, lids, base plate, lead, and seals, in Table 3.1.3-2 (page 3-6 of the application) without identifying or categorizing the results from the top lid impact fire accident or the sidewall impact fire accident. The applicant is required to separately list the component temperatures in Table 3.1.3-2 for the top lid impact fire accident and the sidewall impact fire accident.

RAI 3-6 Response

- Table 3.1.3-2 of the SAR will be expanded to indicate which accident condition scenario is represented
- A second table has been added so that there is one summary table for each of the side impact and top lid impact fire accident events

RAI 3-7:

Explain the inconsistency in the times to reach the maximum lead temperature for the side impact fire accident in Figure 3.4.2.2-3, and the maximum O-ring seal temperature for the top impact fire accident in Figure 3.4.2.2-6.

a) The applicant showed a time of 2077 seconds, which projects to ≈1830 seconds in the X Coordinate of Figure 3.4.2.2-3 (Close-up View), to reach the maximum lead temperature under the side impact fire accident.

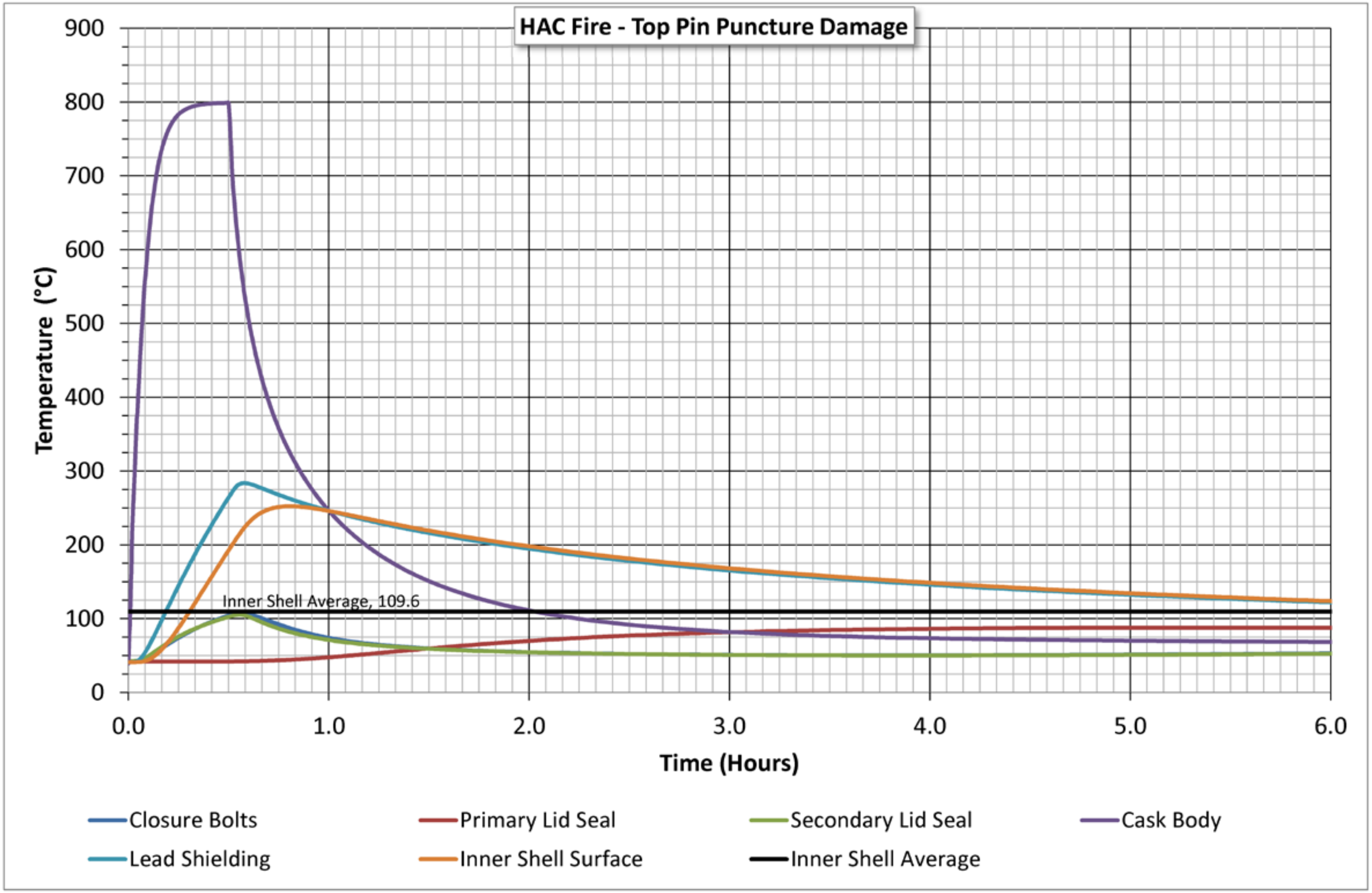
b) The applicant also showed a time of 1957 seconds, which projects to ≈2160 seconds in the X Coordinate of Figure 3.4.2.2-6 (Close-up View), to reach the maximum O-ring seal temperature under the top impact fire accident.

The applicant should clarify this inconsistency, as mentioned in a) and b) above. The applicant should plot the temperature history starting from 0 minute (into the fire) to 300 minutes in the close-up views of Figures 3.4.2.2-3 and 3.4.2.2-6.

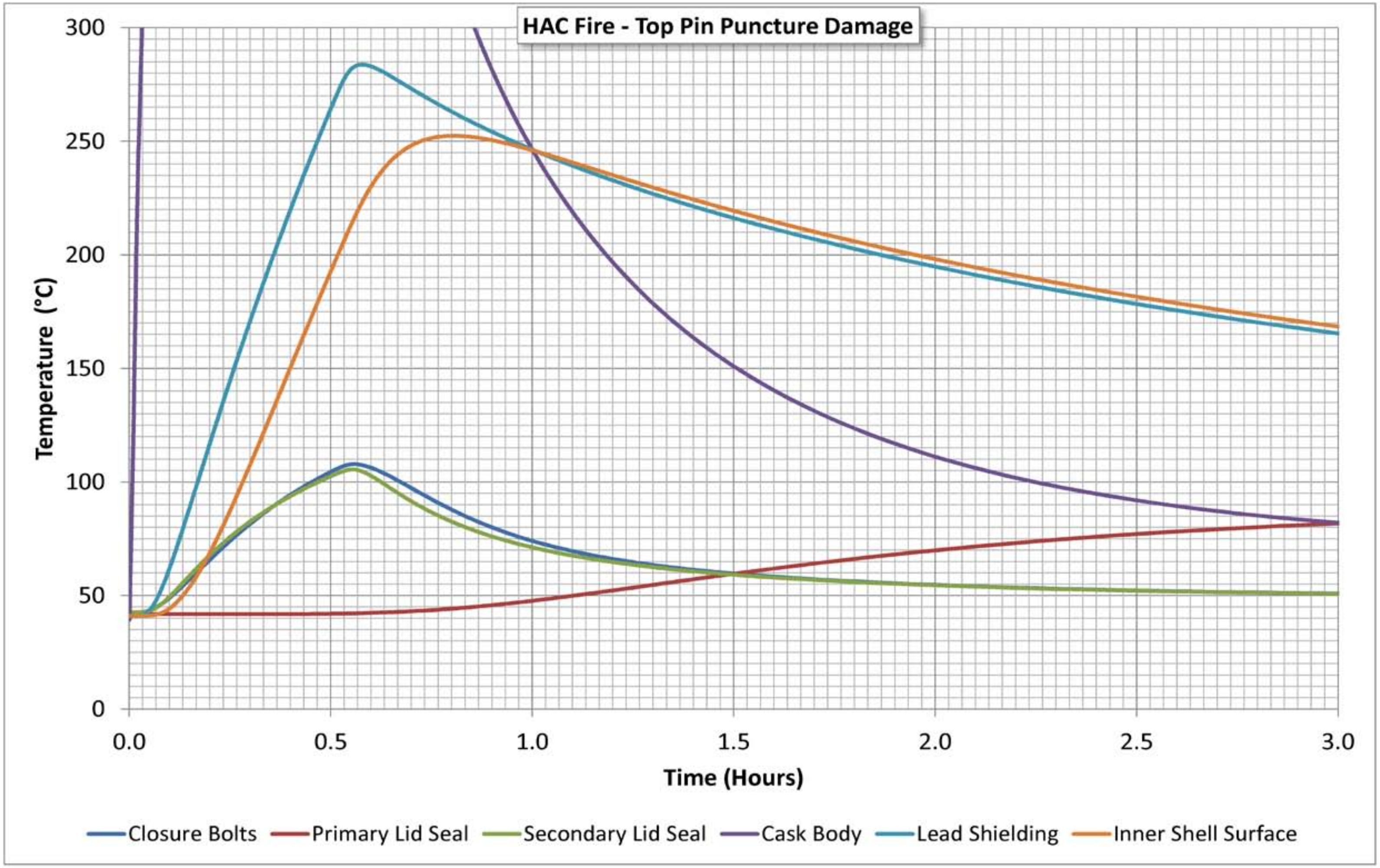
RAI 3-7 Response

- The thermal analysis for the HAC fire accident and post-fire cool-down has been revised as result of other RAI regarding Chapter 3
- As a result, the figures presenting the time history of the lead and O-ring seal temperatures will be revised to present the updated temperature history values
- Additionally, the format has been updated to allow the time in the figures to be presented in a clearer manner
- The revised figures clearly show the time along the x-axis of each figure starting with the beginning of the fire as time = 0 seconds, allowing the reader to verify the time at which the maximum temperatures occur
  - Examples shown on the following slides

RAI 3-7 Response (cont)



RAI 3-7 Response (cont)



RAI 4-1:

Demonstrate that the release calculations are bounding:

a) The containment analysis focused on the activity associated with the resin as a powder, and its corresponding airborne release and respirable fractions. However, there is no discussion of the activity associated with the gases and volatiles of the void, or “head space,” within the package. The effect of the content isotopes’ volatiles and gases, including their quantities, activities, and higher release fractions compared to the solid content, should be detailed and included in the NCT and HAC containment discussion.

b) The calculations in Sections 4.2.2 and 4.3 of the application should be expanded to show all of the potential sources of releasable activity, such as the gases/volatiles (from isotopes and their daughter products) and those leached out (from moisture content) and evolved at NCT and HAC temperatures, in addition to the sources associated with the solid resins and filters.

c) Sections 4.2.2 and 4.3 should provide an additional explanation to justify the appropriateness of the airborne release and respirable fraction calculation methodology and how the resin and filter contents are bounded by it. The density of powder aerosol from NUREG/CR-6487 already takes into account the material suspended in air; thus, including the airborne release fraction (ARF) counts twice the aerosol-effect.

RAI 4-1 Response

- The containment analysis will be revised to address the activities of gases and volatiles in the cask
  - The analysis assumes that gases and volatiles are available for release at 100% of the quantity present in the cask
  - A separate A_2 limit for gases and volatiles is imposed in the evaluation and will be a content restriction in the Certificate of Compliance
- The analysis method is developed on a "per unit activity" basis in the SAR so that end users can develop the loading table for their specific contents and ensure compliance with regulatory requirements
- The containment analysis presented in the SAR will be revised to more thoroughly address the guidance criteria provided by NUREG/CR-6487
  - Analyses are presented for a dispersible solids content type in accordance with Section 3 of the NUREG
  - The contributions from gaseous and volatile radionuclides are treated separately, assuming that 100% of these isotopes are available for release
  - As noted above, a separate A_2 limit for gases and volatiles is imposed

RAI 4-1 Response (cont)

- Proposed activity limits for NUREG/CR-6487 evaluation
  - Dispersible Solid Activity Limit – 425 A_2
  - Gases and Volatiles Limit – 75 A_2
  - Minimum dispersible mass – 60 grams
  - NUREG powdered aerosol density – 6×10^{-6} g/cm^3 (Category II)
- Estimated allowable leak rates
  - Normal conditions – 1.9×10^{-6} std cm^3/sec
  - Accident conditions – 4.69×10^{-3} std cm^3/sec

RAI 4-2:

Discuss the form of the resin bead and filter contents.

The analysis in Section 4.2.2 assumes a powder content form ("density of powder aerosol", etc.) but does not provide details of the resin bead and filter, such as the range of bead diameter, the powder size classification, etc.

RAI 4-2 Response

- As described in response to RAI 4-1, the containment analysis has been revised to present analysis of the contents as a dispersible solid
- Resin beads are typically in a range of 1-2 mm in diameter, and filters are much larger
- Powdered resins have particle sizes in the range of 0.05 mm
- Because these resins and filters are designed to trap radioactive material, it is not anticipated that large quantities of radionuclides would become available for release as an aerosol as per NUREG/CR-6487 guidance
- For conservatism, the revised containment evaluation considers the contents as a dispersible solid
- Therefore, the specific content form of the resin beads and filters is not relied upon in the revised containment analysis

RAI 4-3:

Provide a clearer picture and description of the containment boundary; the image and red line in Figures 4.1.2-1 and 4.1.2-2 on page 4-3 of the application do not clearly show the extent of the containment boundary in the upper right hand side figure.

The resolution of the line and image in Figures 4.1.2-1 and 4.1.2-2 is insufficient to clearly understand the containment boundary. A clearer image and description of the containment boundary should be provided.

RAI 4-3 Response

- Figures 4.1.2-1 and 4.1.2-2 will be replaced by larger and higher resolution pictures to provide a better illustration of the containment boundary

RAI 4-4:

Clarify that the caps associated with the primary lid, secondary lid, and vent port cover plate are listed on the Bill of Materials.

It is unclear from the application's Bill of Materials whether the caps associated with the primary lid, secondary lid, and vent port cover plate are listed on the Bill of Materials in the drawings or not; this should be clarified.

RAI 4-4 Response

- The caps associated with the primary lid and the secondary lid are on the licensing drawing 102885 PE 1001-2 and in the Bill of Materials document RT100 NM 1000, Item Number 1016
- The vent port cover plate leak test port plug is displayed on Section GG of Drawing 102885 PE 1001-2 and referenced in the Bill of Materials as the fourth component of the Subassembly “Staubli cover plate”, Item Number 1017
- The Bill of Materials will be revised to modify the quality category of the leak test port plugs from Category C to Not Important to Safety as they do not provide a safety function

RAI 4-5:

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

Section 4.4 references ANSI N14.5 when discussing the fabrication, maintenance, periodic and pre-shipment leak test. ANSI N14.5 indicates that the entire containment boundary, which includes welds, joints, base material, valves, etc., is part of the fabrication helium leakage test. The extent of the containment boundary that is helium leak tested should be stated in Section 8.1.4 of the application.

RAI 4-5 Response

- The extent of the helium leak test containment boundary are listed in the cask drawings and Bill of Materials as follows:
  - For the Cask Body:
    - Upper flange Item Number 1011-01
    - Inner shell Item Number 1011-02
    - Inner bottom Item Number 1011-03
    - Associated welds S.1011.01, S.1011.02 and S.1011.03
  - For the Primary Lid:
    - Primary Lid (Item Number 1012) without the subparts and the Primary Lid Inner O-ring
  - For the Secondary Lid:
    - Secondary Lid Upper Flange (Item Number 1013-01) and the Secondary Lid Inner O-ring
  - For the Vent Port Cover Plate:
    - Vent Port Cover Plate (Item Number 1017) and Cover Plate Inner O-ring

RAI 4-5 Response (cont)

- Prior to lead pouring, the fabrication verification helium leak test is performed for the cask body
  - Acceptance criteria for this test will be no leakage in the cask body welds (i.e., leaktight)
- Testing is performed for the lids and seals after completion of fabrication
- Chapter 8 of the SAR is revised to clarify the containment boundary extents and the leak test procedure

RAI 4-6:

Confirm that the vent port cover plate's bolts are at the appropriate torque to maintain proper compression of the vent port cover plate's O-rings.

Section 2.14 provides the closure bolt evaluation for the primary and secondary lid.

Similar calculations should be provided for the vent port cover plate's bolts.

RAI 4-6 Response

- Section 2.14 of the SAR will be revised to provide an analysis of the required bolt torques

RAI 4-7:

Justify that combustible gases generated in the package during the shipping period do not exceed 5%, by volume, of the free gas volume.

Section 1.2.2.6 states that the shipper must ensure that the hydrogen concentration within the container will be below 5%, by volume. In addition, page 1-8 states that the moisture content is limited to no more than 1% free water by volume. A bounding calculation of combustible gases that could form, based on the approved contents with their respective alphas, betas, etc., should be provided.

RAI 4-7 Response

- Section 7.8.2 of the SAR will be added to provide guidance to cask users regarding how to calculate the gas generation rate for the contents
- Complete instructions are provided regarding the gas generation factors for the contents, including any water in the container
- Hydrogen gas generation rate parameters from NUREG/CR-6673 are provided for all allowable materials comprising the resin and filter contents and thermoplastic secondary containers
- Cask users calculate the maximum allowable shipping time for the specific contents, ensuring that hydrogen generation would not result in a concentration in the free gas volume in excess of 5%
- Key parameters in the calculation include:
  - Mass of hydrogen generating materials (thermoplastic secondary containers, resins, filters, etc)
  - Mass of water in the cavity
  - Free volume in the cask cavity
  - Decay heat load

RAI 4-7 Response (cont)

- Key parameters in the calculation include:
  - Mass of hydrogen generating materials (thermoplastic secondary containers, resins, filters, etc)
  - Mass of water in the cavity
  - Free volume in the cask cavity
  - Decay heat load
- Bounding calculations are prepared for a set of basic assumptions
  - Shipping time of 10 days (20 days used for hydrogen generation)
  - Maximum proposed quantity of hydrogen generating material
  - Loading curve establishes the allowable decay heat as a function of the free volume in the cavity
- Detailed calculations will be required for contents that exceed any of the parameters used in the loading curve

RAI 4-8:

Clarify where the information related to the EPDM O-rings is discussed.

Page 4-3 states that the EPDM O-rings are addressed in Section 0. This appears to be in error; please provide the appropriate section.

RAI 4-8 Response

- Section 4.1.3 on Page 4-3 of Revision 1 of the SAR will be revised to remove the reference to Section 0.
- Revised wording:
  - "Lids seals are EPDM O-rings supplied by manufacturers such as those in References 10 and 11."

RAI 4-9:

Clarify the calculation used to determine the leakage rate of helium in Calc No. RTL-001-CN-CALC-0101 and provide further explanation for applying Section 4.4.1 calculations, Figure 4.4.1-1, and Figure 4.4.1-2.

a) It appears from the Calc No. RTL-001-CN-CALC-0101 calculation sheet that a "Dmax" is calculated for helium at NCT and HAC conditions. Per ANSI N14.5, however, the determination of leakage rates other than actual conditions is based on using the diameter calculated at the actual condition (e.g., air at NCT or HAC) as an input to the leakage rate calculation. The reasoning for the calculation presented in "Calc No. RTL-001-CN-CALC-0101" should be clarified.

b) Further explanation of Section 4.4.1 calculations and when/how Figures 4.4.1-1 and 4.4.1-2 would be used in practice should be provided.

RAI 4-9 Response

- The properties of air are used in the calculations (presented in Section 4.2.2 of the SAR for normal conditions and in Section 4.3 for accident conditions) determining the leak hole diameter D_{max}
  - This is confirmed in Sections 7.3 and 7.4 of the Calculation RTL-001-CALC-CN-0101
- Conversion of the allowable leak rate to air standard conditions also utilizes the properties for air
  - The same value of the leak hole diameter, D_{max}, is utilized in this calculation, since that is the hole diameter that would result in the air standard leak rate as previously determined
  - The calculation utilizes this leak hole diameter to determine the equivalent helium leak rate that would be allowed under test conditions
  - The calculation and SAR will be revised to provide additional clarification regarding this issue

RAI 4-9 Response (cont)

- Section 4.4.1 of the SAR converts the air standard allowable leakage rate to a test leak rate using helium gas
  - This section presents the conversion from the air standard leak rates presented in Table 4.3-1 to the equivalent leak rate allowables when using helium as a test gas
  - Figure 4.4.1-1 provides the allowable leak rate for a mixture of air/helium as a function of temperature for a cask evacuated to 0.3 atm then backfilled with helium to a pressure of 1.0 atm (revised)
  - Figure 4.4.1-2 is the actual allowable helium leakage rate as a function of temperature that the test would be expected to measure, given the specified air/helium mixture
  - Section 4.4.1 of the SAR will be revised to provide additional clarification

RAI 5-1:

Clarify if the secondary container is required to support a safety function and, if required, provide both the drawings and the detailed operating procedures for the secondary container and its shoring device. Clarify also the term “standard devices.”

Page 1-8 of the application states: “All contents will be packaged in a secondary container (liner).” Section 7.1.2.1 of Chapter 7 of the application requires the use the secondary liner and a shoring device. In addition, the operating procedures instruct the user of the package to use a “process liner as necessary and cap the liner using standard devices.” However, the licensing drawings do not include the design of the secondary container and there appears to be conflicting information through different sections of the application.

It is not clear whether a secondary container, together with its shoring device, is required or not in all cases. Further, it is not clear what the term “standard devices” means in the context of this item. If the secondary container/liner is required, the applicant needs to provide licensing drawings for the secondary container/liner and its shoring devices, and also clarify the use of the secondary container/liner along with a specific description of the “standard devices.”

RAI 5-1 Response

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- Secondary containers and shoring are not required to support a safety function with regards to shielding
  - They can be utilized to facilitate handling of the radioactive material contents
  - No credit is taken for a secondary container in the shielding analysis, either from a positioning standpoint or a radiation attenuation standpoint
  - As a result, drawings of secondary containers are not required
  - Sections 1.2.2.3, 1.2.2.4, and 1.2.2.7 will be revised to clarify the use of the secondary container
- The term "standard devices" refers to tooling associated with the secondary container
  - The SAR text will be revised to clarify this meaning

RAI 5-2:

Confirm that the packaging is used to ship only wastes with a uniform source distribution and that sources with a "point source" geometry are not authorized as contents at this time. Provide specific operating procedures that can determine and assure the uniform distribution of the source in the contents.

The application indicates that (i) the Model No. RT-100 package is designed for shipping general wastes from reactors, (ii) the radioactive sources are assumed to be uniformly distributed, and (iii) the contents are restricted in terms of Curie/gram concentration to assure homogeneity. For these reasons, the application does not provide any shielding analysis for concentrated sources and indicates that the sources will be defined in terms of Curie per gram of content. However, the application does not include clear guidance and/or operating procedures regarding the appropriate determination of authorized contents.

(continued)

RAI 5-2 (continued):

The applicant needs to both confirm the intended contents and develop loading procedures that can determine the eligibility of the contents based on the source concentration (i.e., Curie/gram or Becquerel/gram). The applicant also needs to develop operating procedures to determine the maximum and minimum allowed density of the contents. With respect to the density limits, an average density obtained by dividing the total weight by the total volume should not be used because this method cannot provide information on the uniformity of the contents and of the source in the package cavity. The same principle applies to the source term distribution in the contents, i.e., the user must be given specific instructions to assure uniform distribution of the source in the contents as well.

RAI 5-2 Response

- Shielding evaluations are performed to determine the maximum allowable content activity density in curies per gram that may be present in the cask for each radionuclide
  - The cask user is responsible for ensuring that their contents are sampled, and that the maximum content activity density of any individual waste stream are assumed in the calculation of the Loading Table as described in Section 7.8.1 of the SAR
  - Requirements for waste homogeneity are established in the NRC Branch Technical Position on Concentration Averaging and Encapsulation
  - Section 5.3.1 of the SAR is revised to clarify that the "uniform distribution" of the waste means that it is assumed for the purposes of the shielding evaluation to be uniformly distributed throughout the cask cavity at the maximum activity density
  - This is conservative because it ignores the possibility that portions of the contents will have activity densities lower than the maximum assumed in the analysis
  - The assumptions stated above ensure that the dose rates predicted for a specific waste shipment will bound the actual measured values taken prior to shipment
- As addressed in response to RAI 5-6 and 7-1, Section 7.8.1 of the SAR will be revised to provide additional examples of how the Loading Table is utilized to demonstrate compliance with the individual nuclide activity density limits specified in Section 5.6.3

RAI 5-2 Response (cont)

- Concerning the range of allowed densities of the material, the analysis in Calculation RTL-001-CALC-0201, Rev. 1 demonstrates that resin at 0.65 g/cm^3 produces the lowest maximum allowable Ci/g for each radionuclide
  - Thus, higher and lower density concentrations of resin in the package are bounded by the current evaluations

RAI 5-3:

Explain the basis for assuming the additional 1 mm annular air gap between the lead shield layer and the shells housing the lead layer of the Model No. RT-100 package; justify the adequacy of the subsequent 2.478 cm lead slump assumption; recalculate the lead slump if necessary, and provide an updated loading table for various contents based on the updated lead slump.

The application indicates that lead slump was considered in the HAC shielding analysis. On pages 26-27, the applicant calculated the lead slump for both side and end drop impacts. However, the basis for the air gap formed by the lead slump is unclear. In its response to RSI 5-1, the applicant did not provide any basis for its determination and simply replaced the axial 1.62 mm with a lead slump gap of 2.478 cm in the application. In addition, the applicant characterized the gap as manufacturing tolerance.

(continued)

RAI 5-3 (continued):

It is unclear if the manufacturing tolerances include lead shrinkage. More importantly, it is unclear if the stainless steel shells housing the lead layer have the same tolerances. If so, the space available for lead slump will be much larger when the tolerances move in opposite directions. Further, the staff was unable to find any update to the maximum allowable design basis contents, Table 5.4.4-4, for a package under HAC as a result of this change. The maximum allowable contents in this table are identical to what was presented in Revision 0 of the application.

The staff requests the applicant to provide: (1) a justification for the assumed lead gaps under both NCT and HAC, (2) correct the data if necessary, and (3) recalculate the dose rates for the package under both NCT and HAC.

RAI 5-3 Response

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- The lead pour and solidification procedures and acceptance criteria are included in Chapter 8 of the SAR, including justification for the maximum 1-mm annular lead gap utilized in the calculation of the 2.478 cm axial lead slump present in the accident condition shielding model
  - As described in the revised SAR, the heating and cooling process for the lead pour is closely controlled to ensure that the gap between the lead and the outer shell is minimized during the cool-down process
  - The evaluation of the gap presented in the revised SAR demonstrates that the maximum gap between the lead and the outer shell is less than 1 mm
- Drawing RT100 PE 1001 is revised to clarify that the gap between the inner and outer shells prior to lead pouring is 90 +5 / -4 mm
  - This dimension is measured during the fabrication process to ensure that the minimum lead thickness of 85 mm will be maintained including the subsequent lead shrinkage during cooldown

RAI 5-3 Response (cont)

- The shielding analysis has always been performed assuming a minimum lead thickness at all locations
  - The accident condition model of the cask for lead slump assumes a gap of 2.478 cm at the top of the lead column in the cask body
  - The actual lead slump that occurs, as demonstrated in Section 2.7.1.1.2 of the SAR, is 1.6 mm
  - Therefore, there has been no need to revise the shielding analysis to respond to the RSI comment regarding this issue

RAI 5-4:

Provide justification for the use of material density of 1.13 g/cm^3 for dose rate calculations for package under HAC and revise the analysis with a conservative material density, if necessary.

From Figure 5.3.1-4 of the application, it seems that a material density of 1.13 g/cm^3 was used in the model for the package under HAC. However, it is unclear that the assumed material density is conservative for shielding calculations. Page 5-17 of the application states: "This density is based on the random packing fraction (~0.65) for polystyrene spheres (beads) which has a theoretical density of ~ 1 g/cm^3. Under HAC, the material is conservatively assumed to compress to half its volume and double the source density. Thus under HAC, the contents maximum density increases to 1.13 g/cm^3 due to compression from the drop." From these statements, it appears that 1.13 g/cm^3 was used for conservatism in dose rate calculations. However, this assumption may not be valid and conservative for shielding analysis. First of all, this density exceeds the theoretical density of the polystyrene resin which is the main authorized content. Second, shielding analysis models typically use material densities that are lower than the actual densities. Arbitrary increase in material density will increase the attenuation of the particles traversing the media; hence compaction of the media may underestimate the dose rate outside the package. Although the source was condensed accordingly in the model for a package under HAC, the evaluated configuration may not be the bounding. The applicant needs to examine this approach, demonstrate that the assumed configuration is bounding in terms of dose rates, and recalculate the dose rates for the package.

RAI 5-4 Response

ROBATEL technologies

- The determination of the acceptable maximum Ci/g for the HAC has been recomputed as a function of material density up to the 1 g/cm3 theoretical density for polystyrene resin
- Typical response behavior as a function of resin density for Co-60:

Resin Density	1 meter Dose Rate Response
g/cm^3	mrem/hr/Ci
0.65	0.179
0.75	0.183
0.85	0.186
1.00	0.187
1.13	0.186

- Trade off between resin self-shielding and the increase in source density is essentially constant

RAI 5-5:

Clarify if the package is transported with an enclosure or a personnel barrier. If neither of these devices are used, provide a justification for using the dose rate at 3219.2 mm from the cask centerline of the package for demonstration of compliance with 10 CFR 71.51(a)(1).

Page 5-3 of the application states: “During normal conditions of transport, shielding evaluations assume that the RT-100 is transported on a truck trailer that is 2438.4 mm and 12801.6 mm long with the cask tied downed in the center. Thus, the 2 meter radial surface is 3219.2 mm from the cask centerline and the distance to the cab, taking into account the trailer hookup and the distance to back of cab, is 8915.4 mm from the cask centerline.” Page 1-4 of the application states: “The RT-100 does not require the use of personnel barriers to meet 10 CFR 71 dose rate limits.” As shown on licensing drawing RT100 PE 1001-1, it appears that the diameter of the package body is 2060 mm. If there is no personnel barrier and the package is not transported in an enclosure, the requirements of 10 CFR 71.47(b)(1) apply. The dose rate at 2 meters from the package surface should be 2060/2 + 2000 = 3030 mm rather than 3219.2 mm from the centerline of the package. The applicant needs to clarify this design feature and provide updated shielding calculations and results if the package is not transported in an enclosure or with a personnel barrier.

RAI 5-5 Response

- It is intended that the package be in compliance with 10 CFR 71.47(b)
- The SAR text and tables with reference to 10 CFR 71.47(a) will be revised to reflect 10 CFR 71.47(b)

RAI 5-6:

Demonstrate that the approach used to calculate the maximum allowable content is accurate and reliable for all actual contents.

Table 7.8.1-1 lists maximum allowable contents for each potential isotope in a typical resin waste composition. The application states that this approach is an inverse calculation approach and that the method attempts to determine the maximum allowable quantity for each isotope of interest for the given regulatory dose rate limits. Since a pure nuclide was used in each calculation, it is unclear if the results are applicable to a content that is a mixture of multiple nuclides. The applicant needs demonstrate that this approach is accurate and reliable for determining the maximum allowable content with consideration of the differences between the materials used in the model and the actual contents.

RAI 5-6 Response

- A one curie source dose rate response is computed for each isotope with a greater than 1-day half life
- Self shielding by the nuclide or other nuclides present in the resin is conservatively neglected
  - Only resin or filter material is modeled as the source material
- The dose rate contributions from multiple nuclides are based on the principle of superposition
  - Mixture of multiple nuclides are conservatively evaluated
- Different resin/filter materials: i.e. carbon, polystyrene, etc., have been appropriately evaluated as source materials and their differing self-shielding effects have been consider in Calculation RTL-001-CALC-SH-0201, Rev. 1
- Section 5.2 of the SAR will be revised to provide additional clarifying information
- Section 7.8.1 is also revised to provide additional examples of the loading table process which ensures compliance with regulatory dose rate requirements

RAI 5-6 Response (cont)

Project RT-100 Transport Cask

Task Sample Loading Table Based on St. Lucie LLW Assay

Mass (g) 1950000

Gamma Emitting Nuclides

	Activity (Curie)	Nuclide	Maximum (Curies/gram)	Cask Content (Curies/gram)	% of Maximum	A2 (Curie)	Activity(i) / A2(i)	Watts
	5.57E+00	fe55	1.11E+06	2.86E-06	0.00	1100	5.06E-03	1.89E-04
	7.18E+00	co60	2.48E-04	3.68E-06	1.48	11	6.53E-01	1.11E-01
	5.70E+01	ni63	1.11E+06	2.92E-05	0.00	810	7.04E-02	5.79E-03
	5.95E-01	co58	9.69E-03	3.05E-07	0.00	27	2.20E-02	3.56E-03
	1.07E+00	mn54	9.82E-03	5.49E-07	0.01	27	3.96E-02	5.33E-03
	2.79E-01	cs137	4.12E-02	1.43E-07	0.00	16	1.74E-02	3.10E-04
	6.19E-01	h3	1.11E+06	3.17E-07	0.00	1100	5.63E-04	2.09E-05
	5.01E-03	sr90	1.32E+03	2.57E-09	0.00	8.1	6.19E-04	5.82E-06
	2.53E-02	c14	1.11E+06	1.30E-08	0.00	81	3.12E-04	7.42E-06
	9.14E-01	sb125	7.73E-02	4.69E-07	0.00	27	3.39E-02	2.89E-03
Sum	7.33E+01			**Sum**	1.49		0.84	0.13
				Limit	**100**		**500**	**200**

RAI 5-6 Response (cont)

Project RT-100 Transport Cask

Task Sample Loading Table Based on St. Lucie LLW Assay

Mass (g) 1950000

Volatile and Gas Isotope Inventory

	Activity (Curie)	Nuclide	A2 (Curie)	Activity(i) / A2(i)
	6.19E-01	H3	1.10E+03	5.63E-04
	2.53E-02	C14	8.10E+01	3.12E-04
	5.01E-03	SR90	8.10E+00	6.19E-04
	2.79E-01	CS137	1.60E+01	1.74E-02
Sum	9.28E-01			0.02
			Limit	75

RAI 5-7:

Explain why only the Bremsstrahlung gamma flux at 2 mm from the inner surface, rather than in the entire range of the inner steel shell, was computed and used in the subsequent shielding analysis, and recalculate the contribution of Bremsstrahlung gamma to the total dose rates, if necessary.

The applicant used an indirect method to compute the dose rate contributed by the Bremsstrahlung reactions that occur while high energy beta particles traverse heavy metals such as lead and steel. However, it is unclear why only the Bremsstrahlung gamma flux at 2 mm was computed and used in the subsequent shielding analysis rather than all the gamma particles produced in the entire range of the inner steel shell.

RAI 5-7 Response

- The initial approach presented in the SAR for Bremsstrahlung gamma production has been revised
- Initial approach in RTL-001-CALC-SH-0201, Rev. 1, Section 7.7.7:
  - In order to model this conservatively, the Bremsstrahlung photon spectra produced in the first 2 mm of the inner steel shell was computed using an MCNP tally, conservatively assuming all the source is in direct contact with the wall
    - A predominance of the electrons emitted by the source are absorbed within the first 2 mm of high-Z materials such as stainless steel
  - The resulting Bremsstrahlung photon spectra was then folded into the energy dependent photon responses generated for gamma emission in order used to conservatively assess the dose rate due to Bremsstrahlung
  - Dose rate responses were very low ($< 2 \times 10^{-6}$ mrem/hr/Ci) and basically negligible for resin/filter contents

RAI 5-7 Response (cont)

ROBATEL technologies

- Revised approach will be provided in RTL-001-CALC-SH-0201, Rev. 2, Section 7.7.7:
- Two source configurations
  - Uniform source in resin (polystyrene and zeolite)
  - Uniform source in void, i.e. direct impact on the interior shell yielding highest response
- MCNP transport executed in mode e p (electron-photon)
- Coupled e p weight window variance reduction employed
- Most energetic Beta nuclides evaluated:
  - Y-90 Emax = 2.281 MeV
  - Sb-124 Emax = 2.302 MeV
  - Cs-137 Emax = 1.175 MeV
  - La-140 Emax = 2.165 MeV
  - Ce-144 Emax = 2.996 MeV
- Beta Spectra from ICRU Report 56, Appendix D
- The revised analysis calculates the integrated production of Bremsstrahlung gammas throughout the model rather than just those produced in the first 2-mm thickness of the inner shell as performed in the initial analysis

RAI 5-7 Response (cont)

ROBATEL technologies

- Results for NCT:

Nuclide	Response at 2 Meters (mrem/hr/Ci)
Y-90	6.60E-07
SB-124	1.59E-07
CS-137	1.45E-11
LA-140	3.88E-08
CE-144	1.95E-06
CE-144-void	3.64E-05
CE-144-Zeolite	3.12E-06

- The void case represents the source in direct contact with the inner shell
- Zeolite resin contains aluminum, silicon and calcium producing more energetic gammas
- For comparison, the Co-60 response at 2 meters is 1.28E-02 mrem/hr/Ci

RAI 5-7 Response (cont)

- Beta emitters would produce a maximum dose rate of 0.05 mrem/hr
  - Limiting case is CE-144 in Zeolite
  - CE-144 A_2 value is 5.4 Ci
  - Maximum quanitity of CE-144 is 16,200 Ci (for a limit of 3000 A_2)
- The A_2 limit precludes the shipment of sufficient Curies of the Beta/Bremsstrahlung emitting isotopes to produce a significant contribution to the total dose rate limit at two meters
  - Therefore, the bremsstrahlung gamma response functions are omitted from the Loading Tables described in Section 7.8.1 of the SAR
- The results of this evaluation will be added to the calculation and to Section 5.4.1 of the SAR

RAI 5-8:

Provide justification for including the S(α, β) reaction for the up-scattering treatment of thermal neutrons in the neutron shielding analysis.

The applicant applied the S(α, β) reaction modification to the material cards in its MCNP shielding models. However, it is unclear why such a modification is necessary for the shielding analyses. The applicant needs to provide discussions on the meaning of the S(α, β) reaction modification and why it is necessary to include this treatment in neutron shielding analyses.

RAI 5-8 Response

- It is more accurate to use S(α, β) treatment for thermal neutron scattering as this is a better treatment of up and down energy scattering at thermal energies
- Calculation RTL-001-CALC-SH-0201, Rev. 1, Section 7.7.8 addresses the impact of S(α, β) treatment on the RT-100 shielding evaluations
- Conclusions are that the maximum Ci/g limits for the neutron emitting actinides with and without S(α,β) treatment are within ± 1% of each other and, in general, the computed dose rates per Ci are within Monte Carlo error of one another

RAI 5-9:

REDACTED

Proprietary Information

Refer to separate file

RAI 5-9 Response

REDACTED

Proprietary Information

Refer to separate file

RAI 7-1:

Provide operating procedures and/or instructions for the user to calculate the maximum allowable contents for a mixture of some of the isotopes listed in Appendix 5 of the application.

The applicant provides a list of Gamma Nuclides with Greater than 1 Day Half Life, a list of Gamma Dose Rate Response (NCT) (5.6.2-1), a list of Gamma Dose Rate Response (HAC) (Table 5.6.2-2), and a list of Nuclide Maximum Ci/g Loading Limits (Table 5.6.3-1) in Appendix 5 of the application. However, the applicant did not provide any instructions regarding the use of this data to determine the maximum allowable quantity of contents that are typically mixtures of some of the nuclides. The applicant needs to develop operating procedures and/or instructions for the users to determine the maximum allowable quantity if the contents are mixtures of some of the nuclides.

RAI 7-1 Response

- Section 7.8.1 provides the procedure to be followed by cask users to ensure that the contents are within regulatory limits
  - This section will be revised to provide additional discussion and reference to the appropriate sections of Chapter 5 of the SAR as described in response to RAI 5-6
  - Specific procedures will be provided to guide the user in completing the Loading Table and demonstrating that the contents comply with the loading restrictions for the cask
- Section 7.8.1 will also provide numerous examples of the Loading Table for specific content descriptions

RAI 7-9:

Provide instructions in Chapter 7 that indicate contents are limited such that the concentration of combustible gases must be below 5%, by volume, at the end of the shipping period.

Chapter 7 should provide instructions to indicate that contents are limited such that the concentration of combustible gases must be below 5%, by volume, at the end of the shipping period. In addition, the shipping period should be explicitly stated.

RAI 7-9 Response

- Section 7.8.2 of the SAR will be added to provide guidance to cask users regarding how to calculate the gas generation rate for their contents
- Section 7.8.2 will provide complete instructions regarding the gas generation factors for the contents
  - The maximum combustible gas generation within the cask will be required to be limited to less than 5% in the free volume for a period of time that is twice the expected shipping time after closure of the cask

- RAI schedule
  - Discussion
- Closing statements
- Next steps