Robatel Technologies, LLC
RT-100 RAI Meeting

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

- 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.
  - 69 items to answer and/or clarify.
  - Today's meeting to verify RT's interpretation of NRC's questions.
  - Identification of critical path areas.
  - Proposed approach and strategy for resolution.

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

- On review of the RAI, we have distilled the questions to the following which we would like to discuss:

- Package Contents: 1-1 and 2-1.
- Structural: 2-9, 2-13, and 2-14.
- Thermal: 3-1, 3-3, 3-4 and 3-5.
- Containment: 4-1, 4-2, 4-5 and 4-7.
- Shielding: 5-1, 5-2, 5-4 and 5-5.

Package Contents

- ✓ RAI 1-1, Chapter 1, General Information
- ✓ RAI 2-1, Chapter 2, Structural Evaluation

RAI 1-1 Question:

Provide clarification on the authorized contents described in Section 1.2.2 of the application. Regarding the chemical and physical form, indicate whether the contents are limited to solids and whether powdered or dispersible solids will also be present.

The physical and chemical forms of the contents are described in Section 1.2.2. However, based on the information provided, it is unclear whether the contents will include dispersible solids.

This information is required by the staff to determine compliance with 10 CFR 71.33(b)(3).

RAI 2-1 Question:

Clarify which materials are acceptable for use as (i) secondary containers, (ii) metal housings, and (iii) for shoring. Alternatively, indicate the critical characteristics of these materials, e.g., melting or sublimation temperature, radiation resistance, nobility, etc., necessary to ensure that no inadvertent chemical reactions will occur. Justify the loading restriction that indicates that materials that change phase at temperatures less than 177ºF, not including water, are not included in the contents. Update Section 2.2.2 of the application to assess these allowable materials for chemical, galvanic, or other reactions. This RAI is, in part, a follow-up to RSI 1.1.

A requirement for the use of secondary containers is stated in the application, but acceptable materials to be used for this purpose are not adequately described. It is important to clarify which materials are acceptable for this purpose to ensure that unacceptable chemical reactions do not ensue. The materials must be described with enough detail to make this determination and cannot rely solely on the shipper's judgment. There is a loading condition that states that materials that change phase at temperatures less than 177ºF are not included in the contents; however, this temperature does not appear to correspond to the maximum temperatures stated in Chapter 3 of the application.

This information is required by the staff to determine compliance with 10 CFR 71.33(b)(3) and 71.43(d).

RAI questions 1-1 & 2-1interpretation and proposed answer:

A. Additional limiting assumptions will be added to the SAR to include:

Resins:
- •Material details
- •Temp Limits
- •Chemical compatibility limits

Filters:
- •Material details
- •Temp Limits
- •Galvanic corrosion limits

Secondary Containers:
- •Acceptable materials
- •Temp limits
- •Chemical / Galvanic limits

Structural

- ✓ RAI 2-9, Chapter 2, Structural Evaluation
- ✓ RAI 2-14, Chapter 2, Structural Evaluation

RAI 2-9 Question re: Inelastic deformation

Provide/justify that the containment boundary final geometrical configuration (using a validated model) from the post normal conditions of transport (NCT) free drop and hypothetical accident conditions (HAC) tests correspond to the containment analysis assumptions.

Per RSI 4.2 response, there will be "minor" inelastic deformation on the inner shell (containment boundary).

Section 2.5.7 of NUREG-1609 states that “inelastic deformation is generally unacceptable for the containment evaluation.” Also, Section 4.5.3.2 of NUREG-1609 states that the containment boundary, seal region, and closure bolts should not undergo any inelastic deformation.

RSI 4.2 response and Appendix 2.14 of the application discuss analysis of the closure bolts but do not provide complete insight regarding containment integrity (must remain elastic or the final geometry must correlate to the N14.5 containment analysis).

Staff notes the following statements in RSI 4.2 response: "While some localized areas of the inner shell have minor inelastic deformation, the stresses do not exceed the ultimate strength of the material. Therefore, the ability of the inner shell to maintain positive containment is not compromised." Staff does not agree with this approach, unless the final geometrical configuration is less severe than the assumptions included in the containment analysis.

This information is required by the staff to determine compliance with 10 CFR 71.51.

RAI 2-9 Interpretation and proposed response

The inelastic deformation that occurs in the inner shell is a nodal peak stress, localized to the surface of the material. The section stresses in the inner shell, as shown in Tables 2.7.1-1 and 2.7.2.-1 of the SAR, do not exceed Sy for the material.

According to Section 2.5.1.2 of NUREG-1609, the design criteria for the containment system of Type B Packages can be found in NRC Regulatory Guide 7.6. Position 6 of Regulatory Guide 7.6 addresses accident conditions, and indicates that the acceptance criteria for the containment boundary stress intensity is < 3.6 Sm and $<$ Su. Since Sm is equal to 2/3 Sy, 3.6 Sm would be greater than Sy and thus inelastic deformation would be acceptable as long as the ultimate strength of the material is not exceeded.

This is consistent with the information provided in our RSI response. Because the RT-100 design meets the requirements of RG 7.6, the containment boundary is not compromised and the ability of the design to meet the requirements of 10 CFR 71.51 are maintained.

RAI 2-14 Question re: Lifting

Justify and modify the assembled package lifting analysis.

The detailed assembled package lifting analysis is provided in Section 7.7 of report RTL-001-CALC-ST-0201 and Section 2.5.1.3.1 of the application.

As required by 10 CFR 71.45(a), any lifting attachment must be designed with a minimum safety factor of three against yielding, when used to lift the package in the intended manner.

Per ASME Section III, Division 1, Subsection NF-3323.2, the allowable (corresponding to yield for pure shear) for pure shear stress is $0.6S_m$. When considering this value, the new "yielding" or allowable is less than the S_y/f_{sy} value used.

Section 7.2 of ANSI standard 14.6 (ST-0201 reference 3.12), "Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More," requires a dynamic load factor for the design of critical load lifting. Therefore, the applicant shall provide an analysis using an appropriate dynamic load factor and justify the value used.

It also appears that the analysis is not the same between the calculation package referenced ST-0201 and the application. For example the lifting pocket tear out stress safety margin is calculated to be 4.9 in the application, but only 1.27 in ST-0201. Also, the lifting pocket bearing stress is calculated in the application (safety margin of 1.73), but not in ST-0201.

Ensure consistency between all technical reports, e.g., ST-0201 and the application.

This information is required by the staff to determine compliance with 10 CFR 71.45

RAI 2-14 Interpretation and proposed response

The regulatory requirement (10 CFR 71.45(a)) is to have a safety factor of 3 against the yield strength of the material. The shear allowables in the weld and base metal are taken as 0.6 Sy, before further reduction by the safety factor of 3, in accordance with the classic text "Design of Welded Structures" by O. W. Blodgett. The RT-100 design is not based upon ASME Section III, Division I, Subsection NF-3323.2 acceptance criteria.

The analysis does not currently apply a dynamic factor. The calculation and SAR will be updated to include the dynamic factor.

The addition of a dynamic load factor may require some modification to the lifting design. Additionally, Robatel is considering an external requirement qualify the RT-100 lifting system per NUREG-0612.

Thermal

- ✓ RAI 3-1, Chapter 3, Thermal Evaluation
- ✓ RAI 3-4, Chapter 3, Thermal Evaluation
- ✓ RAI 3-5, Chapter 3, Thermal Evaluation

RAI 3-1 Question re: Solar Insulation

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.

This information is required by the staff to determine compliance with 10 CFR 71.35, 71.71 and 71.73.

RAI 3-1 Interpretation and proposed response

According to 10 CFR 71.71(c)(1), solar insolation is required to be applied for a 12 hours period. This is assumed to be applied in a transient analysis for 12 out of every 24 hours.

Robatel Technologies has adopted the application of solar insolation using a sine function. This is a conservative assumption utilized by Robatel Industries. This has been shown to provide higher maximum temperatures 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.

The approach can be demonstrated to be conservative by running sensitivity evaluations using a simplified model for insolation constantly applied over the 12-hour period in comparison to the sine function application.

RAI 3-4 Question re: Fire Analysis Input

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.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.73.

RAI 3-4 Interpretation and proposed response

The fire transient cases will be reevaluated using the hot, no solar condition, steady state analysis (Hot Condition 2) as presented in the SAR.

This is consistent with Section 3.5.5.1 of NUREG-1609 and 10 CFR 71.73(b) requirements.

RAI 3-5 Question re: Max Temperature Times

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.

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.

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.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.73.

RAI 3-5 Interpretation and proposed response

The fire transient and post-fire cool-down transient cases will be reevaluated using the normal condition hot steady state temperature distribution as described in the RAI 3-4 discussion.

The temperature plots will be normalized to the starting time of 0 at the beginning of the fire, and will provide sufficient close-up detail to enable the time at which the lead and O-ring seals reach their maximum temperatures for each fire transient case.

Containment

- ✓ RAI 4-1, Chapter 4, Containment
- ✓ RAI 4-2, Chapter 4, Containment
- ✓ RAI 4-5, Chapter 4, Containment
- ✓ RAI 4-7, Chapter 4, Containment

RAI 4-1 Question re: Release Calculation

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.

This information is required by the staff to determine compliance with 10 CFR 71.43(f), and 71.51.

Responses to RAI 4-1 & 4-2 combined on slide after RAI 4-2 question

RAI 4-2 Question re: Resin & Filter Contents

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.

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

RAI 4-1 & 4-2 Interpretation and proposed response

The analysis will be revised to utilize the methodology presented in NUREG/CR-6487.

Robatel is currently reviewing the appropriateness of using powdered radioactive materials or surface contaminated non-dispersible solids.

RAI 4-7 Question re: Hydrogen Generation

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.

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

RAI 4-7 Interpretation and proposed response

The SAR will be revised to provide details of the hydrogen generation calculation methodology in accordance with NUREG/CR-6673.

Additional details will be provided in the Containment and Operating Procedure Chapters of the SAR guiding the user to calculate the maximum shipping time for their contents to ensure compliance with flammability limits.

Shielding

- ✓ RAI 5-1, Chapter 5, Shielding
- ✓ RAI 5-2, Chapter 5, Shielding
- ✓ RAI 5-4, Chapter 5, Shielding
- ✓ RAI 5-5, Chapter 5, Shielding

RAI 5-1 Question re: Secondary Container

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.”

This information is required by the staff to determine compliance with 10 CFR 71.47, 71.51, and 71.89.

RAI 5-1 Interpretation and proposed response

Additional clarification will be provided to state that the secondary container is not relied upon for safety.

Wording in Chapter 7 will be revised to clarify the meaning of "standard devices".

RAI 5-2 Question re: Loading Table (5-6, 7-1 related)

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.

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.

This information is required by the staff to determine compliance with 10 CFR 71.47, 71.51, and 71.89.

RAI 5-2 Interpretation and proposed response

The acceptable waste contents are confirmed using the guidance provided in Section 7.8.1 of the SAR, which describes the loading table. This section will be revised to provide additional clarity and more detailed examples to facilitate the end user, who is ultimately responsible for ensuring compliance with the limits specified in the SAR.

The NRC requirements for low level radioactive waste classification and waste form were published in Branch Technical Position (BTP) papers in May 1983. All shippers of waste for subsequent disposal are required to follow this guidance. These BTPs cover the full set of requirements for the wastes to be transported, including requirements on the secondary containers used to contain and ultimately dispose the contents.

Specifically, the guidance requires licensees to have compliance programs in place to determine radionuclide concentrations in their waste. These programs by definition ensure that a user knows the distribution and quantities of radionuclides to be transported. The shielding analysis presented in the SAR is based on MAXIMUM quantities of radionuclides measured in curies per gram. The bounding radionuclide values, as determined by the user, shall be multiplied by the entire mass of the waste to develop the total number of curies of waste that is used to ensure compliance with the loading table requirements in the SAR.

RAI 5-4 Question re: HAC Assumptions

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.

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

RAI 5-4 Interpretation and proposed response

Although the assumption used is conservative in that the number of curies in the top half of the cask is maximized, the analysis can be revised to utilize the theoretical maximum resin density of 1 g/cm^3.

RAI 5-5 Question re: Trailer Width

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.

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

RAI 5-5 Interpretation and proposed response

The analyses are performed using a distance of 2 meters from the "vertical planes projected by the outer edges of the vehicle" as allowed in 10 CFR 71.47(b)(3).

- Schedule
  - March 28, 2013, received Request for Additional Information (RAI).
  - April 17, 2013, Robatel / NRC meeting to baseline understanding of RAIs and express proposed approach.
  - ~May 22, 2013, progress meeting and presentation of preliminary response.
  - ~June 28, 2013, submit formal RAI response.

- Next Steps
- Closing