ENERGYSOLUTIONS

DOCKET NO. 71-9321

OPEN TECHNICAL ISSUES

RELATED TO THE MODEL NO. 3-60B TYPE B(U) PACKAGE

This list of open technical issues identifies additional information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its safety review of the Model No. 3-60B Type B(U) package application. The requested information is listed by chapter number and title in the applicant's Safety Analysis Report (SAR). NUREG - 1609, "Standard Review Plan for Transportation Packages for Radioactive Material," was used by the staff in its review of the application.

The open technical issues listed below include concerns about the validation of the ANSYS/LS-DYNA analysis technique used by the applicant. Staff was not able to perform a thorough review of the structural integrity assessment of the 3-60B package under normal conditions of transportation (NTC) and hypothetical accident conditions (HAC). The staff reviewed the SAR and supporting engineering documents, and have included other additional open technical issues that are either technical or clerical/editorial in nature. It should also be noted that the following issues may or may not change the results adversely, and should not be limited to the issues listed below. The applicant should make its best effort to correct others that may have not yet been identified by the staff.

1.0 GENERAL INFORMATION

1-1 Provide a detailed description of the characteristics of each type and form of permitted contents of the package (Section 1.2.2) including the identification of the main isotopes and radioactive constituents.

Section 1.2.2., "Contents," gives only a general description of the contents of the package and does not include any technical or numerical data.

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

1-2 Provide a demonstration of the determination of flammable gas concentrations for various waste types and contents. Provide this analysis for each package configuration.

Section 1.2.2. states: "The shipper must make a determination before each shipment containing materials that can generate hydrogen that the amount of hydrogen generated will be less than 5% of the cask cavity void volume over a period of time that is twice the expected shipping time. If the shipper does not make the determination on the amount of hydrogen that could be generated, or if the amount of hydrogen that could be generated is greater than 5%, the shipper may ship the package by inerting the cask cavity and secondary container (or the volume containing the potentially flammable gas contents). Inerting shall limit the

oxygen to 5% by volume in the portions of the package that could have hydrogen greater than 5%."

NUREG-1609, Standard Review Plan for Transportation Packages for Radioactive Material, Section 4.5.2.3 indicates that "No credit should be taken for getters, catalysts, or any other recombination devices." Staff understands that inerting is not recombining and that inerting the confinement may be considered on a case by case basis.

1.3 Provide details on the production of flammable gases and how the production of hydrogen varies with time during the shipping period (or twice the shipping period).

1.4 Provide information on the performance of the container dewatering process.

1.5 Provide information on the radiolytic process going on in the container, and the hydrogen/flammable gas production during transport.

1.6 Provide information on how the applicant performs the inerting process during transport.

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

2.0 STRUCTURAL EVALUATION

2.1 Provide complete output files such as d3plot, matsum, glstat for LS-DYNA finite element analyses.

This information is required by the staff to assess compliance with 10 CFR 71.31.

2.2 Provide a sensitivity analysis defending an acceptable level of appropriate mesh density for each case.

The applicant did not address the issue of mesh sensitivity in ST-551, Rev. 1 – especially at critical locations affecting the results – e.g.; in Section 7.0., "Analysis Details," the applicant states that " …the impact region have a relatively fine mesh." Contrary to the applicant's statement, there appears to be no refinement of mesh density.

This information is required by the staff to assess compliance with 10 CFR 71.31.

2.3 Provide rerun analyses with hourglass control turned on.

In Document ST-551, Rev. 1, Appendix 1, there is no justification for the lack of hourglass controls in the analyses given the use of one-point integration elements for the impact limiters. The hourglass energy is calculated to be over 5% of the internal energy based on the results shown on Figures 7 and 16 in document ST-551, Rev. 1. Severe hourglassing was observed at the impact limiter.

This information is required by the staff to assess compliance with 10 CFR 71.31.

2.4 Provide justification for the modeling choices in ST-551, Rev. 1, Appendix 1, D-1621, Test Simulation (PRVAR.xls) and Figure 5 in ST-551, Rev. 1.

Benchmarking of the foam material is carried out only to 60% strain, although the input goes up to 70%. The tension cutoff is also set at 500 psi.

This information is required by the staff to assess compliance with 10 CFR 71.31.

2.5 Provide justification and/or a validation assessment for how acceleration magnitudes compare at different regions in the package. Provide a justification for why this is a conservative assessment.

The applicant states that *"The BAM 65g average acceleration value most likely corresponds to the tail end accelerometer. …conservatively compared with the nose end average value from the LS-DYNA analysis."* (Note 6 in Table 1 of Document ST-551, Rev. 1). Furthermore, Note 4 states: "*The tail-end impact limiter fails during the slap-down test. Therefore the results presented here may not be accurate."* This statement directly contradicts assurance of validation.

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

2.6 Justify how the EnergySolutions validation methodology can use a linear isotropic material to represent cask body behavior under HAC.

Subsection titled "Cask Body Material Model" in Section 7.0 of ST-551, "Analysis Details," states that "…. *a rigid body and is subjected to stress that are mostly below yield stress, it is modeled with linear isotropic material model*."

Based on the 30 ft drop cases at all temperature levels in Section 2.0 of the SAR, outer shell stress levels for all stress categories are well over the yield stress (S_y) of the stainless steel material.

Furthermore, in the Subsection "Impact Limiter Skin Material Model" in Section 7.0 "Analysis Details," the applicant provided material properties that may not characterize stainless steel impact limiter skin (element SHELL163).

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

2.7 Provide references to specific section(s) within the codes and/or regulatory publication(s) for the allowable stress requirements for all service limits that were listed in the SAR.

Section 2.1.2, "Design Criteria," of the SAR only refers to Regulatory Guide 7.6 and Section III, ND-3000 of the ASME Code for stress intensity allowable limits.

This information is needed to determine compliance with 10 CFR 71.71 and 73.

2.8 Provide the definition of "Peak Stress" and show how peak stress values from the computer analyses were tabulated. Provide a justification for using an allowable stress level of two (2) times the ultimate strength (S_u).

The applicant tabulated a service limit of *"Peak Stress"* for HAC in Section 2 of the SAR, and in other sections of supporting documents. Furthermore, the allowable stress limits of the materials under cyclic loading for the normal conditions of transportation should be considered, and compared to the calculated resulting stress levels.

This information is needed to determine compliance with 10 CFR 71.71 and 107.

2.9 Correct Section 2.1.2, "Design Criteria," in the SAR that provides the ASME code requirement for combining stresses for bolt qualifications.

The abbreviations "f_v" and "F_{vb}" were depicted as *"tensile stress"* whereas they should read *"shear stress."*

This information is needed to determine compliance with 10 CFR 71.111.

2.10 Identify and replace each non-quantifiable word such as *"significant, little, large, slight, etc.,"* throughout the SAR with statements that can provide some justifiable/measurable/quantifiable values.

For example, Section 2.2.2, "Chemical Galvanic and Other Reactions", states *"….the package will not cause* significant *chemical, galvanic or other reaction"* : quantify *"significant"* in terms of predicted wear-rate level(s), and recalculate stress levels, if applicable, under NTC and HAC by considering degraded cross sectional properties of critical components that are important to structural integrity.

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

2.11 Provide weld qualification analyses of trunnions under lifting, handling, and transportation loading conditions.

In Section 2.5, titled "Lifting and Tie-Down Standards for all Packages," and document ST-503, Rev. 0, staff identified that welded joints between the trunnions (item 18 on Drawing C-002-165024-001, Rev. 0) and the trunnion-back-up plates (item 19 on Drawing C-002-165024-001, Rev. 0) have the lowest cross-sectional properties under the postulated loading conditions of NCT and HAC.

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

2.12 Provide a detailed assessment of fatigue evaluation under combined stress due to vibration, temperature, and pressure for the components important to maintain the pressure boundary.

Section 2.6.5, "Vibration," states that *"….material that will be unaffected by vibration normally incident to transportation."*

It should be noted that allowable stress limits may also be adjusted for the fatigue condition(s) accordingly.

This information is required by the staff to assess compliance with 10 CFR 71.71.

2.13 Provide a justification for using an allowable stress level of two (2) times the ultimate strength (S_u), and provide the definition of "Peak Stress."

Section 2.7.4.4, "Comparison with Allowable Stresses," states *"A minimum factor of safety of 1.02 occurs……,"* which was taken from Table 2-23, "Maximum Stress Intensities in 3-60B Cask HAC Fire," and Table 3 "Stress Intensities in 3-60B Cask HAC Fire (t=1,813.2 sec)" of the Document ST-501, Rev. 0.

As analyzed, the highest stress intensity level of 170,961 psi occurs in the bolting ring skirt extension under HAC fire condition, and that stress intensity level was compared to the peak stress intensity level of 174,000 psi.

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

2.14 Provide justification for selecting Ultrasonic Testing as the best approach for Non-Destructive Examination criteria for this case

Items 2 under "General Notes" on sheet 1 of Drawing C-002165024-001, Rev. 0, and Section 8.1.2.4 of SAR state that the acceptance criteria of Ultrasonic Testing for welding were chosen for several joints (e.g.; items 6 and 7,…..).

Staff believes that Items 7 and 19 should be included for the same level of acceptance criteria.

This information is needed to determine compliance with 10 CFR 71.129.

2.15 Provide weld symbols for all locations.

Sheet 2 of Drawing C-002165024-001, Rev. 0: Full penetration welding symbols between Items 6 and 7, 6 and 10, 10 and 11, were not identified.

This information is needed to determine compliance with 10 CFR 71.111.

2.16 Provide justification that the trunnions will not be impacted for any postulated orientation conditions under HAC.

Section 2.7 titled "Hypothetical Accident Condition (HAC) in the Safety Analysis Report (SAR)," and associated documents ST-504, Rev. 0 and ST-557, Rev. 0, on the evaluation of drop orientations of end drop, side drop, corner drop and shallow angle drop cases were addressed and performed.

Staff identified in some drop orientations under HAC a condition of impacting trunnion(s) axially at large deformation levels of the impact-limiters (beyond the $8^{1/2}$ inches).

If it were to be concluded that the trunnion could be subjected to impact force(s) under HAC, provide an analysis justifying that the calculated impact force would not breach the pressure boundary of the cask, and that the structural integrity of the pressure boundary is maintained – note: eccentric impact force(s) may provide the worst resultant stress levels.

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

2.17 Provide a justification that a 15° orientation for the shallow angle drop case provides the worst possible results in terms of acceleration levels.

As described in Section 2 of the SAR and associated supporting documents ST-504, Rev. 0, ST-577, Rev. 0, the cask was analyzed for a shallow angle drop case of 15° from horizontal plane to the axis of the cask.

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

2.18 Provide justification and/or assurance on how payloads (contents), as listed in Section 1.2.2 of the SAR, can have a package CG location at its geometric CG.

Section 2.1.3, "Weight and Center of Gravity (CG)," states that *"The CG of the package is located at approximately the same location as the geometric center of the package."* Item 5 in Section 5.0, "Major Assumptions and Simplifications" states that *"…payload and miscellaneous items have been accounted for in the model by increasing the mass density of the cask material."*

Therefore, the applicant assumes that the payload density is equally distributed throughout the axis of the cask. As a consequence, the possible condition of a payload skewed to the geometric CG was not considered.

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

2.19 Provide justification of how an extremely complex prying action in terms of a factor can simply be calculated by taking the ratio of the bolt circular and the seal plate radiuses.

In Section 2.7.1.9 titled "Closure Bolt Evaluation," a prying factor of 1.127 was calculated, and, as stated, *"conservatively a value of 1.2 was used"* to calculate the loads on closure bolts under internal pressure of the package.

The applicant may refer to NUREG/CR-6007, titled "Stress Analysis of Closure Bolts for Shipping Casks," for guidance to qualify the closure bolts.

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

2.20 Provide stress calculations for the inner shell under external pressure using known engineering equation(s) from industrial codes and/or technical publications.

Section D, "Buckling of the Inner Shell," of document ST-549, Rev. 0., defines the equation used to calculate stress levels for cylindrical sections under internal

pressure. However, the internal shell would be under external pressure for NTC and HAC conditions.

This information is needed to determine compliance with 10 CFR 71.72 and 73.

2.21 Provide justification of the impact zone (area) used for calculating the estimated pressure on the drain port assembly. Provide justification(s) for assuming the reaction forces at the attachment locations of the drain port can be equally distributed.

Section C, "Cask Drain Port Assembly," of document ST-549, Rev. 0., Sheet 3, of Drawing C-002-165024-001, Rev. 0, does not provide any weld symbols for the cask outer shell to drain port connection.

This information is needed to determine compliance with 10 CFR 71.71 and 73.

2.22 Provide an analysis assessing the transportation cask shell structure, and closure bolts (if reused) under shock, vibration and fatigue effects.

Section 2.6.5, "Vibration," states that *"The 3-60B package…will be unaffected by vibration….."*

For guidance, the American National Standard Institute, Inc. (ANSI) publication N14.23 provides minimum design standards for shock and vibration in highway transport.

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

2.23 Provide justification why the difference in height of the items described below is not a concern during the fabrication process.

Sheets 1 and 2 of Drawing C-002165024-001, Rev. 0, item 9 *"Spacer Wire"* has a diameter of 3/16," and all-around fillet weld leg for members (Item 47, 56) of impact limiter tie-down lugs was identified as 5/16".

This information is needed to determine compliance with 10 CFR 71.111.

2.24 Provide a justification of how Item 8, "12 gage thermal shield plate," can be seal-welded to Items 47 and 56, "1/2 inch and 1 inch plates," without affecting the structural integrity of 5/16 inch all around attachment welds for the impact limiter tie down lugs.

Furthermore, Section D-D Item 51 on Sheet 2 Drawing C-002165024-001, Rev. 0, identifies all around seal welds for item 8 to Items 47 and 56 that will cause interference with the 5/16" tie-down lug attachment weld.

Also provide information on how Item 9, "spacer wire," will be attached to Item 7 "outer shell," and how Item 8, "thermal shield," will be attached to Item 9.

This information is needed to determine compliance with 10 CFR 71.111.

2.25 Provide a copy of the specification ES-M-172.

In Section 2.2.1, “Material Properties and Specifications,” and Section 8.3.1, “Appendix,” of the SAR, the applicant referred to a specification of ES-M-172 for Polyurethane Foam. Staff is specifically interested in foam material’s structural integrity during its service life, and studies related to degradation mechanisms due to aging effects that could adversely affect the ability of safety related functions during the NTC and HAC conditions.

This information is needed to determine compliance with 10 CFR 71.107 and 117.

2.26 Provide output files that justify the following results.

In folder Reference 2-15 (ST-557) Appendix 2, visual output results were not provided for the drop analyses. However, the energy plots a number of results such as hourglass energy being larger than all other energies, negative total energy, and increasing kinetic energy during a drop analysis – e.g.; Figure 33 of ST-557, Rev 0.

This information is needed to determine compliance with 10 CFR 71.71 and 73.

2.27 Provide justification for all modeling assumptions, including the following:

(1) using link elements for bolt connections,

(2) having three (3) of the link elements per half cask when the fabrication drawings show four (4) bolts, and

(3) using "steel" material properties for the cask by only changing the Poisson's ratio for the lead shield.

This information is needed to determine compliance with 10 CFR 71.71 and 73.

2.28 Provide justification for the following modeling assumptions.

In Appendix 2 of Document ST-505, Rev. 0., the following issues were identified from the "puncture wall" results file:

(1) It is apparent the model shows a steel bar being dropped onto a cask, as opposed to dropping a cask onto a steel bar.

(2) A quarter symmetric model was used. However, symmetry along the long axis of the cask implies impact on opposite sides of the cask.

(3) The applicant did not model a dynamic event, since the analysis type is static. It appears that a pressure is applied instead – the applicant did not provide any explanation for this approach.

(4) The *"puncture lid"* analysis did not contain a puncture bar.

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

2.29 Provide a comparative justification against the elevated temperature levels and fire conditions.

Section 2.7.1.5, "Lead Slump Evaluation," states that *"The most conservative environmental conditions (cold with no decay heat) have been employed in the analysis."*

It should also be noted that due to large differences in thermal expansion coefficients between stainless steel and lead materials, an evaluation due to the lead expansion effect under elevated temperature levels should be provided.

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

3.0 THERMAL EVALUATION

3-1 Provide details of the permitted contents of 3-60B package identifying isotopes, types of materials, types of process solids, and types of activated nuclear reactor or accelerator components. Provide a physical and chemical description of items placed in the package such as the HICs, "secondary containers" and control rod blades.

Section 1.2.2 of the application lists the contents of the cask without specifying list of isotopic contents, and amount and identity of fissile/non-fissile materials. The applicant should provide sufficient details of cask contents by identifying specific sources, special nuclear materials, and activated nuclear reactor or accelerator components or segments of components, to provide an adequate basis for an evaluation of the package.

This information is required by the staff to show compliance with 10 CFR 71.31, and 71.33.

3-2 Explain, in detail, the reason why the fire shield temperature (1379° F) as reported in Table 3-1 and illustrated in Figure 8 of calculation TH-023 is significantly less than the ambient air temperature (1475° F) during fire transient for 30 minutes for the hypothetical fire accident thermal analysis of the 3-60B package.

During the HAC fire test for the 3-60B package, the fire shield temperature is reported as 1379° F where the ambient temperature the package is exposed to is 1475° F. Figure 8 of calculation Number TH-023 indicates that the fire shield and inner shell temperature rises to 1379° F during 1800 seconds and decreases at 1801 seconds.

This information is required to show compliance with 10 CFR 71.71 and 71.73.

3-3 Provide the ANSYS input files for the NCT and HAC analyses.

This information is required to show compliance with 10 CFR 71.71 and 71.73.

3-4 Explain in detail how the impact limiter filler polyurethane foam is treated in the thermal analysis for hypothetical fire accident conditions.

In SAR Section 3.1.1, "Design Features," the applicant stated that "*The impact limiters are shown to remain attached to the cask after the HAC tests (see Section 2.7.1.6). Consequently, only the metal casings, separated by the air gap, are the only thermal protection assumed during the HAC fire evaluation*." Based on Figures 1-3 in TH-023, the region originally occupied by polyurethane is not included during HAC. It is not clear how the region originally occupied by the polyurethane is modeled.

3-5 Explain, in detail, how the HAC thermal analysis treats the foam in the impact limiter during the hypothetical fire accident.

The SAR should indicate whether the foam is replaced by the air of helium during the HAC, the reason for the selection, and describe, in detail, how the analysis is performed with respect to the impact limiter during HAC.

This information is required to show compliance with 10 CFR 71.73.

3-6 Provide a graph of spatial temperature profiles (axial and radial) for various components of the 3-60B cask at various representative times during the hypothetical fire accident.

Table 3-2 lists summary of maximum HAC temperatures for various components of the 3-60B cask. The Table lists the fire shield temperature as 1379° F and the adjacent outer shell temperature significantly less than the fire shield temperature at 263° F. In order to verify the accuracy of the model and understand the thermal behavior of the components of the cask during the hypothetical fire, the applicant should provide a graphical illustration of the spatial variation (both axial and radial) temperature distribution of the various components during the fire at different times during the transient.

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

3-7 Provide the dimension of the air gap between the fire-shield and the cask body.

In the thermal calculation package TH-023, Section 5.0, the applicant states that "The interstitial air gaps between the impact limiter plates and the cask end as well as that between the fire-shield and the cask body are modeled by these elements also." In light of the significant temperature drop from the fire-shield to the outer shell temperature (1379 ^{0}F to 263 ^{0}F), the staff needs to know the gap size to evaluate the thermal model.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33 and 71.73.

3-8 Justify the applicability of the forced convection heat transfer coefficient used in the current model.

In the thermal calculation package TH-023, Section 5.0, the licensee used 10 W/m^{2}-^{0}C as the forced convection heat transfer coefficient during HAC. This

value is based on the IAEA regulation Safety Series No. 37. The applicant needs to compare the cask configuration with the quoted material and justify whether this coefficient is conservative.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33 and 71.73.

3-9 Provide a sensitivity analysis of the forced heat transfer coefficient to demonstrate its influence on the final temperature calculation.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33 and 71.73.

3-10 Explain and justify the thermal boundary condition on the inside surface of the cask.

In the modeling of the internal heat loading, the applicant converted the heat source term into a heat flux boundary condition. This assumption bypasses the temperature calculation of material contents within the cask cavity. With this assumption, the temperature of the cavity content is presumed to be higher than the shell. However, in Section 3.4.3, "Maximum Temperatures and Pressure," the gas mixture within cask is set equal to the average inside surface temperature of the cask. This gas mixture temperature assumption is non-conservative and conflicts with the heat flux assumption.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33 and 71.73.

4.0 CONTAINMENT

4-1 Clarify and revise the containment release analysis of the 3-60B package. Correct the following errors and unclear assumptions identified in the SAR, as described in Open Technical Issues 4-2 through 4-5. Verify that all the assumptions and values used in the revised containment analyses have been appropriately calculated and stated in the application.

4-2 Clarify the apparent discrepancy for the value calculated for P_{a_N} on page 4-5 of the application.

The applicant calculated the value for P_{a_N} in the application on page 4-5 to be 2.05 atm. It appears that the value for P_{a_N} should be 2.19 atm.

4-3 Revise the value calculated for L_{N_IH} on page 4-8 of the application.

The applicant wrote the value for L_{N_IH} in the application on page 4-8 to be 3.19 x 10^{-6} cm^3/s. The value for L_{N_IH} should be 3.15 x 10^{-6} cm^3/s.

4-4 Clarify the apparent discrepancy on the value calculated for M_{mix} on page 4-25 of the application.

In determining the equivalent reference leakage rate for Helium gas, the applicant calculated the value for M_{mix} on page 4-25 of the application to be 7.07 gm/mole. It appears the calculated value should be 11.7 gm/mole.

4-5 Clarify the apparent discrepancy for the value calculated for H on page 4-30 of the application.

In determining the required charge time for a closure lid, the applicant calculated the value for H in the application on page 4-30 to be 12.2 minutes. Staff calculated the value for H to be 7.17 minutes.

4-6 Provide justification for the value of 44,500 cm² on page 4-7 of the application.

In order to calculate the maximum permitted volumetric leakage rate for NCT for irradiated hardware, the value for the surface area was needed. However, the staff could not locate this value in the referenced NUREG/CR-6487.

This information is required by the staff to assess compliance with 10 CFR 71.51(a)(1).

4-7 Justify the assumption on the empty void volume of the cask denoted on page 4-3 of the application.

On page 4-3 of the application, the applicant assumed the empty void volume of the cask cavity to be 25% of the total cavity volume. The applicant has not made it clear the rationale behind this assumption. The determination of the void volume should be based on the volume of the cask cavity and the proposed contents and internal configuration of devices that secure the contents.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51(a)(1).

4-8 Clarify the condition listed on page 4-4 of the application that states $A_2 / S_A \geq 1.0$ and specify how the cask user will verify this parameter.

On page 4-4 of the application, the condition is a basis for the containment analyses with another statement that this condition will be part of the Certificate of Compliance if L_{N_PS} is found to be the controlling leakage rate. The applicant has not made it clear how the users verify and comply with this requirement.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.51(a)(1).

4-9 Revise the hydrogen generation discussion and provide supporting calculations, and required handling procedures for the calculations of flammable gases, as described in Open Technical Issues 4-10 through 4-17.

This information is needed to assess compliance with 10 CFR 71.43 and 71.73.

4-10 Describe the RADCALC code used to calculate hydrogen generation and provide a validation study or other reference that describes the accuracy of the hydrogen concentrations predicted by the code.

4-11 Specify the methods and assumptions implemented in the RADCALC code in the calculation of hydrogen and oxygen generation.

The licensee used RADCALC code in calculating hydrogen and oxygen concentrations. However, no detailed description was given in the SAR on the methodology, limitations, and input assumptions for the calculation. The staff needs this information to verify the results of the calculation.

4-12 Revise the MNOP calculation to specify the amount of combustible gases generated from radiolysis in the analysis.

MNOP calculation in Section 3.3.2 includes partial pressures of air, hydrogen and oxygen – 17.84, 13.98, and 6.99 psi respectively. It's not clear to the staff how the initial pressures are determined. Based on the calculation, the radiolytic gases are present in the initial loading.

4-13 Clarify the physical, chemical, and nuclear characteristics of the contents and containers used in the radiolysis analyses.

Section 3.3.2, "Maximum Normal Operating Pressure," states that the amount of hydrogen and oxygen generated after one year was calculated using RADCALC (Reference 3-9) for the waste forms identified in Section 1, for a maximum activity (30,000 Ci. of Co-60), and conservatively assuming 100% gamma absorption. For radiolysis, alpha decay is much more effective than gamma decay. The staff needs to know whether assuming 100% gamma absorption is a conservative approach. Based on the proposed contents, the applicant should clarify whether alpha decay is a dominant process in the package.

In Section 1.2.2, "Contents," the SAR states that the "contents shall be packaged in secondary containers." No detailed descriptions are found in the SAR regarding the material and configuration of secondary containers. The SAR further stated in Section 3.3.2, "Maximum Normal Operating Pressure," that the other water loaded waste form assessed is Swarf. Swarf is assumed to be contained in a high density polyethylene liner (HIC) dewatered to 1% of the liner volume, leaving a water volume of approximately 4 gallons in the cask cavity. It's not clear whether the polyethylene liner is the secondary container or just one layer of the secondary container configuration. The staff needs this type of information on the secondary container(s) configuration to evaluate the hydrogen concentration.

4-14 Revise the application to ensure compliance with an hydrogen concentration limit of 5%. Alternatively, justify that the maximum hydrogen concentration for the package will not jeopardize the containment safety of the design.

Section 3.3.2 provides a summary from calculation of maximum internal pressure (MNOP) in the cask. Section 3.3.2 states that *for the irradiated hardware case assessed above, the hydrogen concentration at the end of one year is 4.6%*. It

further states that *for the swarf case, the hydrogen concentration at the end of one year is greater than 5% concentration*. The applicant further states in the SAR that *for a swarf HIC, or any other package containing substances that could radiolitically generate combustible gases in excess of a 5% concentration, as was determined for irradiated hardware, an evaluation shall be performed that demonstrates that one of the following criteria are met over a period of time that is twice the expected shipping time: (1) The hydrogen generated does not exceed a 5% concentration in the secondary container* and *(2) The secondary container and cask cavity must be inerted with a diluent to assure that oxygen does not exceed a 5% concentration at STP in any portion of the package which could have a hydrogen concentration greater than 5%.* Section 3.3.2 of the SAR further indicates that swarf HIC, or any other material could radiolitically generate combustible gas in excess of 5% concentration.

The applicant should examine the proposed contents, hydrogen generation mechanisms, and handling procedures to ensure that combustible gases comprise less than 5% (by volume) of the free gas volume in any confined region of the package. The staff requires the licensee to limit the production of flammable gases less than 5% by volume of the total free gas volume within any confined region in the package. Credits should not be generally taken for getters, catalysts, or other recombination devices.

4-15 Describe specific procedure in determining combustible gases contents, if any, by the cask user.

Section 1.2.2 states: "*The shipper must make a determination before each shipment containing materials that can generate hydrogen that the amount of hydrogen generated will be less than 5% of the cask cavity void volume over a period of time that is twice the expected shipping time. If the shipper does not make the determination on the amount of hydrogen that could be generated, or if the amount of hydrogen that could be generated is greater than 5%, the shipper may ship the package by inerting the cask cavity and secondary container (or the volume containing the potentially flammable gas contents). Inerting shall limit the oxygen to 5% by volume in the portions of the package that could have hydrogen greater than 5%."*

However, in Section 7.1, "Package Loading," procedures could not be found regarding these procedures for shippers. The applicant should list the process for this combustible gas content determination in Chapter 7, "Package Operations."

4-16 Clarify the nitrogen inerting operation to clearly show that the process will prevent the development of flammable gas mixtures in any confined area of the package throughout the entire transport period.

The applicant requests to use a nitrogen inerting procedure to limit the oxygen concentration below 5%. The licensee needs to provide a detailed evaluation analysis to demonstrate that there are no flammable gas mixtures (considering worst case concentrations of hydrogen or any other flammable gases, and oxygen) during the transport period, typically considered to be one year.

4-17 Demonstrate that the nitrogen inerting process effectively prevents the creation of flammable mixtures during the entire transport period. To ensure the nitrogen is introduced effectively to the innermost packaging or other confined areas within the containment system, the licensee needs to provide a detailed configuration of the secondary containers and the characteristics of the package contents.

4-18 Define the leak path between the secondary container and the cask.

In the application, the applicant states "If a leak path can develop between the secondary container and the cask, the cask will also be inerted."

The applicant should clearly show that both the inner container and the cask cavity are properly inerted prior to shipment. The applicant needs to clarify this definition in the operation procedure for the users to make a determination if the cask is to be inerted.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.43 and 71.71.

4-19 Specify and justify the seal properties for the 3-60B package and provide detailed information on the seals material such as identification of the specific elastomer, its mechanical, materials, thermal and chemical characteristics.

4-20 Justify the maximum allowable temperature of the seals listed in Tables 3-1 and 3-2 of the Safety Analysis Report.

Section 3.2.2 of the SAR specifies that *the seals used in the package are specified to be elastomer, 50-70 Durameter, temperature range -40° F to 300° F.* Table 3-1, “Summary of Maximum NCT Temperatures” and Table 3-2, “Summary of Maximum HAC Fire Temperatures,” list the maximum allowable temperature for the seals as 450° F, which is higher than the maximum specified in Section 3.2.2. The applicant should clarify this discrepancy.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.43, 71.71 and 71.73.

5.0 SHIELDING EVALUATION

5.1 Provide more details on the location of the point detectors.

These locations are not specified and are only vaguely described on page 5-3 as “points of expected maximum dose rates.”

This information is required to assess compliance with the requirements of 10 CFR 71.41.

5.2 Provide more details on the role of the “second surface detector” mentioned on page 5-3, played in determining dose rates and justify its radial dimension.

It is not clear which surface detectors are used to determine dose rate at the cask surface.

This information is required to assess compliance with the requirements of 10 CFR 71.41.

5.3 Provide an explanation of the determination of the dose rate in the event that both point and surface detector results are obtained from the same location and the fractional standard deviation (FSD) is unacceptably large.

Page 5-3 of the application explains that the larger of the two tallies is used "unless" the FSD is unacceptably large but offers no information on how this is determined in the case where the FSD is large.

This information is required to assess compliance with the requirements of 10 CFR 71.41.

5.4 Provide a justification of the methods used to model swarf gamma intensity. Provide a determination of the "correct output dose rate."

The swarf is compressed into 20 cm tall cylinders at both the top and the bottom of the cask. In Sections 5.4.1 and 5.4.2 it is claimed that the "activity of the source has to be doubled to get a correct output dose rate." This "correct" dose rate is not quantified, nor is a basis discussed.

This information is required to assess compliance with the requirements of 10 CFR 71.41.

5.5 Provide a summary explaining the purpose (axial, radial, etc.) of each of the 8 models for both NCT and HAC and the modeled cask contents.

Currently, the description and explanation or purpose of changes to the source specification is not clear.

This information is required to assess compliance with the requirements of 10 CFR 71.41.

6.0 CRITICALITY EVALUATION

Not applicable. Contents exceeding the fissile mass limits set forth in 10 CFR 71.15 are not authorized.

7.0 OPERATING PROCEDURES

7-1 Describe the specific procedure used by the cask user for determining combustible gases contents, if any.

Section 1.2.2, "Contents," states "*The shipper must make a determination before each shipment containing materials that can generate hydrogen that the amount of hydrogen generated will be less than 5% of the cask cavity void volume over a period of time that is twice the expected shipping time.*"

Section 7.1, “Package Loading”, does not include any such procedure. The applicant should list the process for this combustible gas content determination in Chapter 7, “Package Operations.”

8.0 ACCEPTANCE CRITERIA AND MAINTENANCE PROGRAM

8-1 Explain the reason for the lack of thermal acceptance tests to demonstrate the heat transfer capability of the 3-60B packaging after fabrication and during the service life of the package as described in Chapter 8. Clarify if thermal tests are performed as part of the maintenance program.

The thermal tests may be needed to confirm that heat transfer performance is consistent with the thermal analyses given uncertainties in calculations, fabrication, or aging of the package during its service life. The staff would like to verify that the maintenance program remains adequate to assure packaging effectiveness for the 3-60B package. If thermal tests are performed, the application should indicate the frequency, method of testing, and the equipments used in the tests.

This information is required by the staff to assess compliance with the requirements of 10 CFR 71.33(b)(7), 71.71(c), 71.73(c), 71.85.