1. *The language in Section 1.2.2.2 is still not quite good enough. The language as proposed in the 2nd round RAI question 5-1 should have been used. The concern is with alpha,n reactions. Some of the fissile exempt limits in 71.15 allow for significant amounts of material. With certain (conservative) assumptions about the material and the source, the alpha,n source could contribute noticeably to package dose rates. (As long as don't have a material, such as beryllium, in the package that results in alpha,n source, the fissile material quantities in 71.15 would be fine.)*

   Response
   The sentence in 1.2.2.1 has been changed to:
   Materials producing neutrons through α,n or γ,n reactions and materials, other than fissile materials as allowed in the preceding sentence, producing neutrons through spontaneous fission are not authorized.

2. *Does the NCT corner point source calculation use the cask side surface for determining the source strength for NCT conditions? The point source is placed in the top corner where the package surface is the radial surface of the impact limiter; however, if the source were at the package's axial midplane, the package surface is the cask surface. A look at the input and output files for the 0.5 MeV gamma case along with Tables A3-11 and A3-12 seem to indicate that the correct surface is used; however, it is not clear that the dose rate was taken from the appropriate segment of the surface (at least for this case). Also, explain why it makes sense that the dose rate at the side of the impact limiter surface is (would be) larger (or more limiting) than the dose rate at the cask side surface. The calculation package Tables A3-1 thru A3-11 indicate this is so, but it doesn't seem right.*

   Response

   The shielding analysis will be revised so that two point source locations are evaluated for the unshored NCT case gamma/sec limit analyses. In addition to the location at the top corner of the cask cavity, a location on the side of the cavity, directly across from the cask body side exterior surface (below the top impact limiter) will be analyzed. For each gamma energy, the maximum allowable source strength will be determined based on the source location (of the two analyzed) that yields the highest package surface dose rate.

   Two locations need to be evaluated because there are competing effects. For the cavity side location, all the gammas must pass through the lead, but the cask body surface (directly across from the source point) is relatively close to the source point. For the cavity top corner source location, a large fraction of the gammas will pass over the lead (and only have to pass through steel). However, the package surface is significantly farther away from the source point, since the cavity top corner lies well above the bottom of the top impact limit. Thus, the package surface is on the outer radial surface of the top impact limiter.

3. *Address the uncertainties in the method and account for these in the method, or justify (using as much of a quantitative evaluation as possible) that the conservatisms in the method account for the uncertainties in the method. Since, the allowable source contents are determined by back-calculating from the dose rate limits, uncertainties in the method should be accounted for as part of demonstrating the dose rate limits are met. The uncertainties include such things as the MCNP uncertainty, uncertainties arising from using the maximum contents density when other lower densities may result in higher dose rates, etc.*

   Response

Three sources of uncertainty have been identified. These include the statistical error level in the MCNP dose rate results that control maximum allowable source strengths, the (small) increases in dose rate seen for lower source material densities that are seen for some energies, and the uncertainty as to whether zirconium is the lowest attenuation material at the 0.5 MeV gamma energy. It should be noted that any increase in dose rate for lower source material density is not believed to be a "real" effect, based on theoretical considerations as well as analyses using non-statistical shielding codes. It is instead believed to be due to statistical fluctuations in MCNP dose rate results (which is plausible given the magnitude of the observed dose rate increases relative to the level of statistical error in the MCNP results).

These uncertainties will be evaluated and/or quantified, and a corresponding discussion will be added to SAR Chapter 5. A qualitative discussion of sources of conservatism in the analyses will also be added. If possible, the use of a 5% administrative margin (i.e., a maximum allowable source strength (vs. limit) fraction of 0.95) to account for all uncertainties will be justified.

4. *Clarify or modify the statement in the second full paragraph on page 21 of 56 (calculation package) regarding the gamma source strength limit applicability that starts with "For any other type of payload…" It would seem that this discussion is limited to only reduced-volume payloads and not payloads that fill most of the cask cavity. I'd also note that the applicant's own calculations indicate that the statement in the same paragraph regarding HAC bounding the centered NCT point source is not true at all gamma energies; the statement may need modification.*

   Response

   The analyses that place a point source in the worst location within the cask cavity (in the NCT cask configuration) are used to determine the gammas/sec limit for payloads that fill the cask cavity, as well as for smaller payloads that are not shored. All gammas/sec limits are conservatively determined using point source analyses, and such a point source must be placed in the worst possible cavity location in order to clearly bound a cavity-filling payload, since such a payload will have source material at all locations within the cavity. (Note that cavity filling payloads will qualify under the gammas/sec-gram limit, in almost all cases.) A clarifying sentence will be added to the calculation package.

   It is true that the centered NCT point source case is not bounded by the (unshored) HAC case for all gamma energies. The sentence stating that the centered NCT case is always bounded by HAC is unnecessary and will be removed from the calculation package.

5. *Clarify/confirm that if the volume of the contents is bounded by the 2.5 ft^3 or 55 gallon volume but not the dimensions on height and diameter analyzed by the applicant then the columns in the source limits table for these two volumes cannot be used to determine the contents' acceptability.*

   Response

   That is correct. A payload (or payload container) must meet the limits on volume, height and diameter specified in the bulleted paragraphs in Chapter 7, Attachment 1 of the SAR, in order to qualify for the shored, reduced-volume case source limits. Source containers that do not meet all three requirements must use the next larger size case (if there is one), or use the source strength density limits (gammas/sec-gram) that are determined for the full-cavity payload case.

No revisions to the SAR or calculation package text are currently planned.

6. *Activity (such as by activation) may not be uniform throughout its volume/mass. Explain how the method accounts for this, or justify why this condition doesn't need to be considered.*

   Response

   The limits on gammas/sec clearly bound any source configuration, regardless of distribution, since the analyses model the total source strength of the entire payload (including all payload components) as being concentrated into a point (with no self-shielding) that is placed in the worst location within the cask cavity.

   The limits on gammas/sec-gram are conservatively applied to the "hottest" material (with the highest source density, in gammas/sec-gram) that occurs anywhere within the payload. This does not mean the payload/source component (or waste item) with the highest (average) source density. It means the highest source density material that occurs anywhere within any payload component (or waste item). No source density averaging of any kind is ever allowed. Not only is source density averaging between waste items not allowed, but averaging the source density within a given waste item's material (or envelope) is not allowed. Thus, the analyses that determine the limits on gammas/sec-gram are very conservatively based on filling the entire cask cavity (or smaller, defined source region) with the highest source density material that occurs anywhere within the payload.

   Text will be added to the SAR which clarifies that the gammas/sec-gram limits must be applied against the highest activity density that occurs anywhere within the payload (accounting for variations in activity density within payload items, as well as between different payload items).

7. *Confirm that interpolation of source limits between volume sizes and gamma energies is not allowed.*

   Response

   Interpolation between size cases and between gamma energies will not be allowed. The user will have to round up to the next larger size case. For gamma sources, the limits that apply for the next higher evaluated gamma energy will have to be used. Text in the SAR will be revised as necessary to make that clear.

8. *I'm not sure about using the lower fraction to limit (y/sec v. y/sec-g) is necessarily the way to select which limit is appropriate for a set of contents. It seems that the appropriate limit should be selected based on the contents' characteristics. (See discussion of this in Chapter 7 Attachment 1 and Calculation package Appendix 4. One part of that discussion talks about limits for small sources – see also response to RAI question 5-6.a. What is considered as small source?)*

   Response

   We believe that a rigorous, analytically-based approach that ensures all qualified payloads are bounded by the analyses (and their results) would be better than an approach where the methodology (i.e., the choice between the gammas/sec and the gammas/sec-gram limit) is based upon a qualitative, subjective determination (by the user) of what "type" of payload is being loaded (e.g., is it "concentrated" or "distributed").

With respect to maximizing peak cask exterior dose rates, an analysis which models the total overall payload source strength as a point source, with no source self-shielding, at the worst location in the cask cavity is bounding for all payload configurations (i.e., all source distributions, source region envelope volumes/dimensions, source material types, source material densities, etc..) whose total source strength (at the gamma energy in question) does not exceed the source strength modeled in the analysis. Similarly, an analysis which models the maximum activity density that occurs anywhere within a payload, throughout the cask cavity, will calculate peak cask exterior dose rates that bound those produced by any actual payload configuration (regardless of source region dimensions, source distribution, material composition or density, etc..). This assumes that a bounding source material density (9.0 g/cc) and the minimum mass attenuation material is modeled in the analysis.

Given the above, using the lower of the two (source/limit) fractions is always justified, since the analyses that determine both the gammas/sec and the gammas/sec-gram limits are conservative (bounding) for all payloads (i.e., all payload shapes, sizes, masses, densities and materials, etc..). The analyses demonstrate that any payload with an overall source strength under the calculated gammas/sec limit cannot cause cask exterior dose rates above the regulatory limits. They also demonstrate that any payload that contains no material with an activity density (in gammas/sec-gram) over the calculated limit will not yield cask exterior dose rates above the regulatory limits. Thus, if <u>either</u> or those two conditions are met, cask exterior dose rate limits cannot be exceeded.

For a payload with a given activity density (or gammas/sec-gram), the relative restrictiveness of the gammas/sec and the gammas/sec-gram limits is a function solely of the payload's mass. There is a certain mass (equal to the gammas/sec limit divided by the gammas/sec per gram limit) where the qualification fractions determined using the two approaches would be the same. Other factors like payload material composition and density have no effect, since all of the analyses are based on a conservative upper-bound density of 9.0 g/cc, and the material (usually zirconium) that has the minimum mass attenuation.

Some discussion of the above points will be added to Chapter 5 of the SAR, as necessary, to clarify why using the lower of the two source/limit fractions is justified.

9. *The paragraph after the bulleted list in Chapter 7, Attachment 1 and calculation package App 4 talks about radiologically distinct objects. What about a package filled with resins/filter(s) but some of the filter/resins is/are hotter than the rest? This isn't necessarily a different item. So, how would this be handled and what would define when these parts are looked at separately (vs. when don't need to)? I would think that averaging would not apply in this case*.

<u>Response</u>

No averaging of any kind is ever used to qualify payloads. If a payload contains components (e.g., filters) which have varying activity density (gammas/sec-gram) levels, the highest activity density (of the "hottest" item) is compared to the gammas/sec-gram limit. In fact, the "hottest" material or section within the "hottest" filter would be compared to the gammas/sec-gram limit. The sum total source strength (in gammas/sec) of all the payload components (e.g., the sum of the activities of all the loaded filters) would be compared to the gammas/sec limit.

Although the procedure strictly allows it, there is never any benefit (to the user) from splitting the cask payload into multiple components that are each qualified under the gammas/sec limit, or multiple

components that are each qualified under the gammas/sec-gram limit. Doing this would yield the same sum of fractions in the gamma/sec limit case, and would actually increase the sum of fractions in the gamma/sec-gram limit case (as was shown in Example #5 in SAR Chapter 7). That is because the gammas/sec-gram limit fraction determined using the single payload component approach would be the same as the highest of the fractions determined using a multiple component approach (both being based on the "hottest" component).

The benefit from payload splitting only comes when a small volume of high activity density material is split off from the rest of the (much lower activity density) payload. The high activity density material(s) is qualified under the gammas/sec limit and the rest of the payload is qualified under the gammas/sec-gram limit. Examples include a "hot wrench" within a liner filled with resin beads, etc.. Given that the mass of the "concentrated" (high activity density) payload item is very small, it will qualify under the gammas/sec limit, despite the fact that its activity density is well over the gammas/sec-gram limit. Splitting off this high activity density payload item greatly reduces the maximum activity density that has to be compared to the gammas/sec-gram limit for the rest of the payload. This lowers the gammas/sec-gram limit fraction by a much larger amount than the value of the gammas/sec limit fraction (determined for the hot, concentrated item) that now must be added to the gammas/sec-gram limit fraction.

This (payload splitting) approach reduces the final total fraction, but still ensures that the payload satisfies both the NCT and HAC dose limits (since both the gammas/sec-gram limit analyses and the gammas/sec limit analyses are conservative and bounding, as discussed in the response to Question #8).

The text or set of examples presented in the SAR may be revised to provide more clarity on these issues.

10. *Clarify when something would not be considered a significant enough source to factor into the evaluation (see the paragraph following the one referenced in the preceding question).*

<u>Response</u>

The cask user will have to characterize all waste materials that are to be loaded into the cask. Thus, the isotope activity levels, and corresponding energy-dependent gamma source strengths, for all payload components must be determined (whether the activity levels are small or large).

In the case of gamma emitters, the activities (or source strengths, in gammas/sec) of all payload components are summed together for comparison to the corresponding gamma/sec limits, as long as the gamma energy level is at least 0.3 MeV. Compliance with the gammas/sec-gram limit is based upon the highest activity density (or gammas/sec-gram) payload material, for each gamma energy level (so very low activity payload sources would be screened out, or bounded, by the stronger sources within the payload).

In the case of beta emitters, isotopes with peak beta energies under 0.3 MeV are neglected. The beta source strengths for all other (beta-dominant) isotopes, including all daughters, are summed. If the resulting total is under 2×10^{12} betas/sec, betas may be neglected in the shielding evaluation. If the sum exceeds 2×10^{12} betas/sec, then the beta source (from each isotope) is converted into an equivalent gamma source using the methodology shown in Chapter 5 of the SAR and in Appendix 7 of the calculation package.

Some additional text may be added to the SAR for further clarification.

11. Comments on Qualification Procedure (Calculation package and Chapter 7 Attachment 1)
Responses follow the comment:

a. *Step 1 should include a determination of the density for each material type, though a payload total would not be appropriate for density. The 'y/sec-g' term should be followed by 'for the hottest portion of the material type'.*

Additional, clarifying text will be added.

b. *Step 2 should include a statement that beta sources with maximum energies greater than 3.5 MeV are not acceptable for transport. Terms and symbols should be defined, including stating how $_{Zw}$ is calculated. The step should define what constitutes the 'beta absorbing material'. This definition should keep in mind that the absorbing material may be the secondary container, especially for beta sources that are in the periphery of the contents next to the container wall. The applicant should justify the definition of this term and ensure that the package user will easily and correctly determine the appropriate materials to use to determine $_{Zw}$. Also, the last sentence should add '(s)' to 'equivalent photon source' since there may be more than one in a package.*

A statement about betas with maximum energies over 3.5 MeV not being allowed will be added. The reference to the "beta absorbing material" will be replaced with "payload material". The paragraph will also be revised to state that the weighted-average Z of the payload material or the Z of the liner wall, whichever is higher, will be used. "Photon source(s)" will be used in the last sentence.

c. *Step 3 should have the first sentence modified so that the calculation is of y/sec for each payload item/material type and y/sec-g for the hottest portion of each payload item/material type for each photon energy. It should also explain how the energies in Table 1 are used for gammas grouped into energy groups (i.e., the energies are the maximum energy for the energy group). The step states there are energy groups in Table 1 while the Table only lists specific energies (not groups); so, it is not clear how energy groups fit with the energies listed in the table.*

The recommended text revisions and clarifications will be added/incorporated. Whether individual gamma energies are grouped or treated separately, all gamma sources must be evaluated using an evaluated gamma energy level that is equal or higher.

d. *Step 4 should include the conditions about the material/item type density (i.e., must be less than 9.0 g/cc to use a y/sec-g column) and to refer to the conditions on using the 2.5 ft^3 and 55 gallon shored volume columns stated near the beginning of Chapter 7 Attachment 1 (App 4 of calculation package). The concern is that the user will focus only on the section titled 'Qualification Procedure' and miss the conditions necessary for use of various limits in Table 1. The second sentence should be modified to replace the word 'surveyed' with 'of the item.' As noted in another question, it seems that only one column should be used, and the appropriate column is determined based on the source's characteristics (this comment also touches on Step 5's selection of the smallest fraction to determine contents acceptability – for example, will one gamma energy use a y/sec limit and another gamma energy use a y/sec-g limit? This wouldn't make sense.).*

A sub-step will be added to Step 1, to determine the density of each payload item and note if any materials have densities in excess of 9.0 g/cc. In Step 4, a statement will be added, saying that if the

density exceeds 9.0 g/cc, only the gammas/sec is determined. A reference to the 2.5 ft3 and the 55 gallon case requirements, and how they govern the chosen Table columns, will be added to Step 4. “Surveyed” will be replaced by “of the item”. It may be possible, and allowed by the procedure, for the applicable limit (gammas/sec vs. gammas/sec-gram) to change for different gamma energies (for a given physical payload configuration).

e. *Step 6 should have ‘and tally the fractions from each payload item over all of the payload’ added to the end of the step. Step 7 would then have the word ‘running’ deleted. Not sure what is intended with that in Step 7 anyway.*

   Will add the task of summing the fractions to Step 6, and will remove “running” from Step 7.

f. *In general, Chapter 7 Attachment 1 and App 4 of the calculation package should be consistent throughout (including figures) in referencing/defining a portion of the package contents/payload, whether this payload type, material type, payload item (type), or some other nomenclature. The documents do not refer to the same things/objects consistently. The term used should be consistent with how the procedure is to be applied and may need to be defined somewhere in the procedure.*

   A review which compares the two SAR chapters and the calculation will be performed, and one or more of those documents will be revised so that the nomenclature between them is consistent.

g. *Explain the ‘*’ after ‘5’ in the box for ‘Use Limits in Columns 3 & 4 or 5.’ It is not clear what the asterisk is for (e.g., is there a missing note that should be at the bottom of the figure?)*

   The asterisk in the Figure 1 flowchart will be removed. It has no purpose in the latest SAR revision.

h. *The examples should be revised to include consideration of all beta sources with maximum energies greater than 0.3 MeV in accordance with the proposed qualification procedure. For example, both Cs-137 and Co-60 emit betas with maximum energies over this threshold. So, in Example 1, the outcome of Step 2 is not ‘Not applicable’ but rather that the beta source strength is less than the minimum necessary for considering that source. As another example, consideration of all the beta sources in Example 2 would yield a total beta source strength that is just above the minimum strength requiring evaluation of the beta sources.*

   The SAR will be revised to clarify that the beta evaluation is only to be performed for pure beta emitters, i.e., a **beta emitter** with no accompanying gamma radiation such as H-3, P-32, S-35, Sr-90, Y-90, and that betas may be neglected for isotopes that are primarily gamma emitters, such as Co-60. This is based on the knowledge that for isotopes that emit a significant number of gammas (relative to the number of betas), the betas will contribute an insignificant fraction of the cask exterior gamma dose rate. The examples will be revised, as necessary

i. *In Example 4, is the small activated steel item a 100 cc item or a 100 g item? It is listed one way at one point in the example and the other way later on. It can’t be both. Also, the consideration of shoring this item doesn’t seem to make sense. How could it be shored to be at the center of the package with the 100 ft^3 secondary container holding the payload in the package? It would have to be shored within the secondary container in the midst of all the other package contents in that container. That doesn’t seem to be practical. The example should be fixed to address these questions.*

The reference to a 100 cc item was in error. It will be revised to refer to a 100 g item. The example does indeed refer to a concentrated source that is shored within a large, inner container. Shoring within cavity liners is common. While it would be possible to shore concentrated sources within a reduced volume container, it is a less common practice. We may consider revising the example to refer to a concentrated source within a full-cavity linter.

12. *Example 5 has contaminated soil. It appears that qualification is based on what consideration will yield the fraction that will be less than 0.95. As in a preceding question, it seems that consideration of a payload as separate components or all one component should be based on the characteristics of the payload components (vs. what is the smallest fraction or what sum will be less than 0.95). So, justification is needed as to why this approach is acceptable (i.e., will consistently result in payloads that meet the dose rate limits). Also, there appears to be no consideration for any settling/concentrating of the activity still in the soil (and not immobilized by the grout). This settling/concentration can occur as a result of NCT as well as HAC. The 10 ft^3 of void in the secondary container may or may not influence this phenomenon. So, it is still not clear how the method addresses this kind of situation. It would seem that the point source column (column 1 in Table 1) would be the appropriate limit for the contamination in the soil and not the column 2 limit. This question on settling/concentration of the source during NCT and HAC should be addressed in general as well as in terms of the example. Also, compression of contaminated filters during HAC should be addressed as part of the question.*

    Response

    See the response to Question #8 with respect to the use of the lowest of the gammas/sec and gammas/sec-gram limit fractions, as opposed to basing the qualification on “payload characteristics”.

    The SAR will be revised to clarify that the gammas/sec limit applies for all types of surface contamination, unless that contamination is chemically or physically bound to the bulk waste form (as it is with resin beads). This includes contaminated soil as well as surface contamination on large waste items (e.g., activated metal components). Given that such surface contamination has negligible mass, the gammas/sec limit must be used if that contamination could possibly concentrate itself or otherwise separate itself from the bulk material.

    The SAR will also be revised to say that the gammas/sec limit should be used in cases of highly activated fine particulates (including powders or fine granules) within a colder bulk waste form, that have potential for concentration or re-distribution. If it is practical to determine the activity density (gammas/sec-gram) within the highly activated fine particulates, we may write the SAR to preserve the option of using the gammas/sec-gram limit for that material. Since the activity density of the particulate is being compared to the gammas/sec-gram limit, the payload could not cause unacceptable cask exterior dose rates, regardless of any redistribution of the particulate within the cask cavity.

13. *In Appendix 7 of the calculation package, the beta absorbing material should be defined and the definition justified (see preceding question on this for the qualification procedure section). Clarify that the equation for Z_w is used for both compounds and mixtures. Clarify whether or not the secondary container material is included. It seems it should be. In the case of a point source near the container wall, it seems that the container wall may be the only material appropriate to consider in determining Z_w. Thus, the determination of Z_w should be modified to address both of these conditions too (both here and in the qualification procedures of the calculation package and Chapter 7 Attachment 1).*

Response

See the response to Question #11b.

The text will clarify that the weighted-average Z of the payload or the Z of the secondary container, whichever is higher, will be used. The payload weighted-average Z calculation will consider either compounds or mixtures. It will be clarified that the "beta absorbing material" is either the payload material or the secondary container wall material.

14. *Confirm that the HAC beta source calculation in Appendix 7 of the calculation package was done with a point source in the package top corner. Confirm that the NCT validation calculations were done with point sources at the package cavity side and top surfaces (or top corner, using the cask surface as the radial package surface). The NCT validation calculations should include these scenarios.*

Response

The (recently added) HAC beta evaluation, which confirms that the minimum threshold beta source of 2×10^{12} betas/sec never yields significant cask exterior dose rates, even for the highest energy betas, is based upon a full cask model with a point beta source in the top corner of the cask cavity.

The NCT validation calculations were based upon beta (and gamma) sources inside simple, 1-D shielding material spheres, whose component thicknesses correspond to the (NCT) cask radial and top shielding geometries (i.e., a steel-lead-steel sphere to represent the cask side, and a thick steel (only) sphere to represent the cask ends). The radius of the inner surface of the spherical shielding materials corresponds to that inner radius of the cask cavity. The beta (and gamma) sources are evenly distributed within the (void-filled) interior. Dose rates are tallied on the outer surfaces of the sphere.

The purpose of these (NCT) validation models is not to determine absolute dose rates, but to verify that the formula used to convert beta sources into equivalent gamma sources (described in Appendix 7 of the calculation package) is conservative. One run models a beta source within the sphere and tallies the gamma dose rate on the surface of the sphere. A second run models the equivalent gamma source (as determined by the Appendix 7 formula) inside the sphere, and also tallies the gamma dose rates on the sphere outer surface. The two gamma dose rates are compared to estimate the level of conservatism in the Appendix 7 formula (and methodology). The results, also presented in Appendix 7 of the calculation (in Table A7-2), show that the formulaic method is extremely conservative, with the exterior dose rates determined using the more rigorous approach (where MCNP models the creation of gammas form betas, and tracks the gammas through the shielding) being more than a factor of 100 lower than the exterior dose rates determined using the formulaic approach.

After beta sources are converted into equivalent gamma sources (using the extremely conservative, formulaic approach), the resulting gamma sources are compared to the gamma source term limits, which were determined using gamma shielding analyses that rigorously model the cask configuration.

15. *For response to RAI 5-4, what about consideration of the parent-daughter combinations of ^{110}Ag (IT) + ^{110}Ag (beta) and ^{144}Ce + ^{144}Pr. The half-lives of the parents in each combo seem to be significant, at least enough for consideration of the beta from the daughter being in the package at the time of*

shipment. The daughters in both cases have betas with maximum energies of about 3 MeV. For the calculation in the response, clarify the Z_w that was used (if 26, then good).

Response

The HAC MCNP analysis referred to in the response to RAI 5-4 rigorously modeled the beta energy distribution for $^{90}Sr/^{90}Y$, whose maximum beta energy is 2.245 MeV. Beta energy distributions have only been found (in literature) for a small number of isotopes. Beta energy distributions for higher beta energy isotopes such as ^{110}Ag and ^{144}Pr have not been located.

To evaluate the potential impact of higher peak beta energy, an additional MCNP evaluation will be performed which models the maximum allowable peak gamma energy of 3.5 MeV. The 20-group beta energy distribution modeled for $^{90}Sr/^{90}Y$ will be assumed for the 3.5 MeV case. The minimum and maximum beta energies for each group (defined for $^{90}Sr/^{90}Y$) will be multiplied by 1.559 (i.e., 3.5/2.245) in order to retain the same distribution shape, while "stretching" the energy bins so that they extend from zero to 3.5 MeV. Thus, the evaluation will assume that the beta energy distribution for a hypothetical 3.5 MeV (peak) beta emitting isotope will be similar to the distribution that occurs for $^{90}Sr/^{90}Y$.

The "Z_w" parameter only applies when the formula (described in Appendix 7 of the calculation package) is used to convert beta sources into equivalent gamma sources. This was not done for the HAC MCNP evaluation referred to in the RAI 5-4 response. A beta source was directly modeled in an MCNP analysis of the actual cask configuration, and the dose rate on the one meter plane was calculated. Thus, no formula, or "Z_w" parameter, is used or determined. MCNP directly treats the conversion of betas to gammas in the shielding materials.

16. Clarify the meaning of Step 7.1.9A to "Process liner as necessary." Clarify that this includes use of axial shoring, as needed, to prevent axial movement of contents during shipment.

    Response

    Process means to modify the waste, usually to meet disposal requirements and may include dewatering or solidification. Step 7.1.9A will be revised to include the installation of axial shoring as needed to prevent movement of contents during shipment.

17. The new shielding acceptance test language should be revised to clarify what value is that the term 'maximum value' refers (e.g., maximum dose rate). Also the change of the pre April 1, 1999 fabrication acceptance test to the current SAR test may be fine. However, it is still necessary to clarify/explain how the acceptance criterion ensures the minimum shielding is in place for compliance with the licensing drawing. Not knowing what the 'normal' lead thickness is makes it difficult to determine that the test criterion and the drawing specification are consistent.

    Response

    The acceptance test language will be revised to state that the maximum value is the maximum exterior dose rate. The acceptance test for pre- 1999 fabrication is only applicable to the casks already built. All future fabrication, including repairs, will be accepted per the new acceptance test.

18. *Inconsistencies/editorial corrections:*

a. *Section 5.1.2.3 indicates the results in Table 5.1 have a 5% margin/administrative limit; however, based on the HAC results in that table, these statements appear to be incorrect.*

The HAC result of 1000 mrem/hr presented in Table 5.1 is in error. It will be corrected to read 950 mrem/hr.

b. *The basis discussion regarding the minimum beta strength to consider (see Section 5.4.4) appears to be inconsistent with the new shielding evaluation for gamma sources and should be modified to provide an appropriate basis.*

The SAR Section 5.4.4 will be updated to reflect the current basis (shielding analysis) for determining the minimum beta source strength threshold (i.e., the HAC cask model analysis)

c. *Notes 11 and 12 appear to be reversed from how they are used in Tables A3-1 through A3-11 (calculation package).*

The notes are reversed. This error will be corrected in the next revision of the calculation package (which will be completed before the SAR submittal)

d. *The phrase (and similar ones to it) 'portion surveyed' should be changed to 'portion of the payload.' (Attachment 1 of Chapter 7 and calculation package App 4)*

The language will be revised as suggested

e. *The applicant should check for errors/inconsistencies throughout the documents. The ones listed here are the ones I noticed and marked.*

The calculation package and SAR Chapters (5 and 7) will be reviewed for errors and inconsistencies.