71-9321

ENERGYSOLUTIONS

30 June 2009
E&L-065-09

Mr. Pierre Saverot
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Revised Application for Energy*Solutions* 3-60B,Docket No. 71-9321 and TAC NO. L24186

Dear Mr. Saverot:

Enclosed for your review and approval please find Energy*Solutions'* revised Safety Analysis Report (SAR) for the 3-60B Package. The application has been revised to address the concerns raised in your letter dated October 30, 2008. Energy*Solutions* hereby requests issue of a Certificate of Compliance (CoC) for this new cask design.

There are six parts to this submittal:

1. Revised SAR
2. Cask drawing, which is to be withheld from public disclosure as security-related sensitive information per 10 CFR 2.390
3. Proprietary references to the SAR, which support the demonstrations of compliance in the SAR
4. Non-proprietary references, which support the demonstrations of compliance in the SAR
5. A proprietary information affidavit for the proprietary references and data
6. A response to each of the issues raised in your October 30, 2008 letter.

In addition to the paper copies of the documents, the associated data files are provided on computer disks (OSM) as noted below. Please appropriately dispose of the documents previously submitted and replace them with those provided herein.

Oak Ridge National Laboratory will be using the 3-60B to ship expended targets from the Spallation Neutron Source Facility. The SNS is a one-of-a-kind multi-million dollar facility that provides critical support to worldwide research projects that require intense pulsed neutron beams. The first target is expected to be ready to ship in the fall of 2009.

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Because limited storage is available, the lack of a shipping option could jeopardize continued facility operations, which would affect numerous international neutron research projects. In order to support the facility operations, we respectively request the issue of the CoC as soon as possible.

Should you or members of your staff have questions about the responses, please contact Mark Whittaker at (803) 758-1898.

Sincerely,

Mirza I. Baig
Technical Services Manager – Engineering & Licensing

Submittal Components:

001	Attachment 1	3-60B SAR, Rev. 0
002	Attachment 2	Cask Drawing (withhold as security-related sensitive information)
003	Attachment 3	Proprietary References and Corresponding Proprietary Data (OSM#1)
004	Attachment 4	Non-Proprietary References and Corresponding Non-Proprietary Data (OSM#2)
005	Attachment 5	Affidavit for Holding Documents and Data as Proprietary
006	Attachment 6	Response to Technical Issues

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.

RESPONSE:

The cask is intended for use a general purpose waste cask. The specific types of contents vary. The contents description is intended to provide limits for the critical characteristics of the contents to allow a demonstration of compliance.

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, "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. 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.

RESPONSE:

The methodology for determination of flammable gases is given in Chapter 3 and examples of application of the method are provided.

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).

RESPONSE:

The methodology for determination of flammable gases is given in Chapter 3 and examples of application of the method are provided.

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

RESPONSE:

The cask is dewatered by draining through the drain port. The steps for performing this operation are provided in Chapter 7.

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

RESPONSE:

The radiolytic process for generation of hydrogen is discussed in Chapter 3 Section 3.2.2.

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.

RESPONSE:

Inerting will not be used to limit the production of flammable gases and has been deleted from the SAR.

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

RESPONSE:

All the files generated by each LS-DYNA analysis have been included on the hard drive in appropriate folders. These folders include d3plot, d3thdt, matsum, glstat, rcforc, etc. files. The input and output files for each analysis are also included. They are named as follows:

Input files: file.k

Output files: d3hsp

An animation file is also included in each folder, which could be examined for the deformation of the package during the drop test.

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

RESPONSE:

A sensitivity analysis of the mesh size used in the 3-60B LS-DYNA analyses has been performed. This study is documented in EnergySolutions proprietary document ST-596. It is referenced in the SAR and is included in the submittal.

The results of these study show that the mesh refinement of the model does not have any significant effect on the analyses performed. It further shows that the refinement of the mesh size beyond the level used in the analyses tend to smoothen out the higher

frequency response, which results in slightly smaller impact limiter reactions. Therefore, the ES selected mesh size provides conservative results.

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

RESPONSE:

The FEM analyses of ST-551 and ST-557 have been revised. It has been pointed out in the write up of these reports that there are several means of controlling the hourglass and negative contact energy in LS-DYNA analyses. One of them is the use of fully integrated formulation for the shell and solid elements, which does not result in any hourglass energy. However, the fully integrated solid element formulation is not as robust as the single point formulation and causes numerical instability, especially in the high strain regions. The new analyses judiciously use the combination of the two formulations in various regions to obtain virtually hourglass energy free simulation. In addition to this control, several other controls have also been employed in all the simulations. These controls are fully described in the proprietary documents ST-551 and ST-557. Please note that for every simulation, plots of hourglass energy have been obtained and examined to ensure no accumulation of hourglass or negative contact energies. These plots are included in the documents.

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

RESPONSE:

The computer simulation of the foam material benchmarking has been run to 70% strain. Since the benchmarking test is run monotonically in the compression zone, the choice of tension cutoff stress of 500 psi is arbitrary. It has been specified only to complete the material input data requirement. The results of the revised simulation are included in ST-551, Rev.2.

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.

RESPONSE:

Note 4 is a statement of the fact that the BAM report gives a single average value of the acceleration obtained from the entire slap down test (impact on both nose and tail-ends of the cask). In the prototype test a few ratchet binders connecting the two impact limiters failed during the tail-end impact. Therefore, it is logical to assume that since the impact limiters were not totally effective, the cask acceleration recorded during the test is higher than if the impact limiters had performed as intended. Therefore, the average acceleration reported in the BAM report is conservative.

Note 6 point out that the acceleration during the slapdown is higher for the tail-end impact. However, the LS-DYNA calculated nose-end impact acceleration is conservatively compared with this value.

Note 4 has been reworded to better explain the above fact.

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 73.

RESPONSE:

During the HAC drop tests, the impact limiter skin material nonlinearity has a tertiary effect on its reaction - the desired result from the LS-DYNA analyses of the 3-60B Cask. The material nonlinearity model used in the analyses – bilinear kinematic hardening model for which the tangent modulus has been derived from the actual material data – makes the impact limiter skin slightly stiffer than other material models. Since the stiffer skin will absorb a lesser amount of energy for a given deformation, the bilinear kinematic representation is considered to be conservative.

The write-up in Section 7.1.3 of ST-551 and ST-557 has been revised to explain this more clearly.

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.

RESPONSE:

Specific references to the Regulatory Guide 7.6 Regulatory Position and/or ASME Code Paragraph have been added to Section 2.1.2 and Tables 2-2 and 2-3.

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.

RESPONSE:

Table 2-3 has been added in the SAR that defines various stress categories. The sources of definition (Regulatory Guide 7.6 Regulatory Position and ASME Code) are also identified in this table. Their implementation in the 3-60B Cask evaluation process is also listed in this table.

It is pointed out that the stresses obtained from the FEA include the stress concentration due to discontinuities. They may also include the stress concentration due to modeling simplifications such as union of two sections of different mesh density, reentrant corners, and contact between two surfaces. In an elastic material these stresses redistribute themselves over a larger area than predicted by the FEA. Nonetheless, since these stresses are reported in the FEA results, their disposition is necessary. The 3-60B Cask analyses categorize these stresses as, $P_m + P_b + Q + F$ and call it "Peak" stress as short term for "primary membrane + bending + secondary bending + peak" stress.

It is pointed out in Table 2-2, Note 6 that Regulatory Guide 7.6, Regulatory Position 7 and ASME Section III, Division 3, WB-3221.9 criteria of limiting these stresses to $2S_a$ @ 10 cycles results in higher than $2S_u$ allowable values. The limits for "peak" stresses are conservatively set to be $2S_u$.

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.

RESPONSE:

The typographical error has been corrected.

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.

RESPONSE:

The non-quantifiable have been removed to the extent that is practical. Section 2.2.2 has been totally rewritten.

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.

RESPONSE:

As shown in drawing C-002-165024-001, the trunnions are made in two pieces - Items 18 & 19. Item 18 is welded to Item 19 with a circumferential 1" groove plus ½" fillet weld. Item 19 is welded to the outside shell of the cask by a compound weld that is specified to be full-penetration double-bevel plus ½" fillet.

In the ANSYS finite element model of ST-503, both the fillet welds are conservatively neglected. Since the model includes both parts of the trunnion, the welds, and a portion of the outer shell, the stresses in the assembly is appropriately computed. Since welds have equal or greater strength than the base metal, the qualification of the base-metal also qualifies the welds.

Please note that in the finite element model Items 18 and 19 are connected only at the weld location. The interface between the two items other than the weld is modeled by contact elements, which provide only one-way contact. The comment by the reviewer that the welds have the lowest cross-sectional properties is totally valid. However, the advanced modeling techniques used in the analyses of ST-503 have incorporated this fact.

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.

RESPONSE:

Evaluation of the components subjected to fatigue due to vibration has been added to the SAR (Section 2.6.5.1). This evaluation is based on the ANSI N14.23 standard. It shows that the RMS vibration loadings are very small and the 3-60B cask will not be subjected to any fatigue during its operating life.

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.

RESPONSE:

Please see the response to 2-8.

In addition it should be noted that the high stress levels during the HAC fire test occur at the juncture of the fire-shield and the outer shell of the cask. The high stresses are due to differential expansion of the two components. Thus they can be classified as secondary stresses. The austenitic stainless steel has a large ductility and can go through large strains without failure.

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.

RESPONSE:

Since RT and UT are both volumetric methods, Note 2 has been revised to state either RT or UT shall be used. Most of the welds will be able to be RT examined prior to lead

pour; however, welds between items 6 and 7 and between items 11 and 10 will have to be UT examined after the lead pour. The weld between items 7 & 19 has been revised to allow RT or UT examination instead of PT.

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.

RESPONSE:

Weld symbols have been added to sheet 2 for the welds between items 6 & 7, 7 & 10 and 10 & 11.

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.

RESPONSE:

An evaluation of the 3-60B Cask under various HAC drop tests conditions in a configuration such that the trunnions are located in the vertical plane, has been performed. This evaluation is included in ST-505. It is concluded that the trunnions could directly impact the rigid surface during the slapdown test. The trunnions have been analyzed for such an impact and shown that they can withstand this drop without exceeding the allowable stresses. Please see Section 7.3 of ST-505 for the results of this evaluation.

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.

RESPONSE:

The angle at which the maximum amount of slapdown occurs is a function of several parameters that include the geometry and impact limiter characteristics. The SANDIA report (SAND-90-2187C) has provided a parametric study of slapdown analyses. Based on the results of these studies it appears that a 7.5° inclination may give maximum slapdown effect for most casks. However, in order to ensure that the effect of slapdown is completed evaluated, the analyses have been performed for two orientations (cask axis at 7.5° and 15° with respect to the horizontal plane). These orientations are identified as Slapdown-1 and Slapdown-2, respectively, in the SAR.

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.

RESPONSE:

The most common contents of the 3-60B cask will be irradiated hardware. In a typical irradiated hardware shipment the irradiated components and sections of components are loaded into the secondary container in the most space efficient manner possible to maximize the amount of waste in a shipment. With this space efficient loading, there is a minimum of void space and the weight of the waste is evenly distributed over the cask cavity.

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.

RESPONSE:

The finite element models used for the analyses of the NCT and HAC events have a detailed representation of the bolting interface. The details of the seal plates in the cask

body and the lid, their welds, gaps, the bolt-head recess into the lid, etc., all are included in the model. Therefore, the stresses in the cask, including the bolted joint, are accurately calculated from these models.

The calculations in Section 2.7.19 were added for a conservative estimation of bolting loads. These calculations have now been replaced with new ones that are based on NUREG/CR-6007. It is shown that the bolting joint provides a large margin of safety.

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.

RESPONSE:

The buckling analyses from ST-549 have been removed. A new document ST-600 (Reference 2-xx) has been provided that performs the buckling evaluation of the 3-60B Cask, using the ASME, Section III, Nuclear Code Case N-284. The results of the analyses show that the cask design provides sufficient margin against buckling during the NCT and HAC events.

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.

RESPONSE:

The calculations in ST-549 have been updated. The revised write up explains the analysis approach in more details.

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.

RESPONSE:

Evaluation of the components subjected to shock loading has been added to the SAR (Section 2.6.5.2). This evaluation is based on the ANSI N14.23 standard. It shows that the shock loadings are very small and the 3-60B sustains these loadings with a large margin of safety.

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.

RESPONSE:

An additional weld detail has been added depicting a space between Item 9 and the 5/16" weld.

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.

RESPONSE:

An additional weld detail has been added depicting a space between Item 9 and the 5/16" weld.

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 10CFR 71.107 and 117.

RESPONSE:

The Energy*Solutions* specification ES-M-172 has been provided as Attachment 1 of Chapter 8 of the SAR.

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.

RESPONSE:

All the files generated by each LS-DYNA analysis have been included on the hard drive in appropriate folders. These folders include d3plot, d3thdt, matsum, glstat, rcforc, etc. files. The input and output files for each analysis are also included. They are named as follows:

Input files: file.k

Output files: d3hsp

An animation file is also included in each folder, which could be examined for the deformation of the package during the drop test.

It should be noted that ES has further improved the analysis techniques to have better control over the hourglass and negative contact energy. The new computer runs use these techniques. Please see ST-551 and ST-557 for further explanation of these controls.

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.

RESPONSE:

The modeling assumptions and justification have been provided in Section 5.0 of the documents ST-551 and ST-557. The specific comments are addressed below:

(1) The impact limiters are attached to the cask by specially designed assemblies that include 7/8" diameter rods. In order to calculate the loads in these rods, appropriate diameter link elements connecting the impact limiter to the cask at their approximate locations have been used. Please see Section 7.1.5 for further details of the attachment modeling.

(2) The analyses have been revised to include 8 (4 in half-model) elements.

(3) The cask body is included in the LS-DYNA model mainly to represent the mass distribution of the package. The overall stiffness of the cask in the model can be adequately represented by assuming it to be made of elastic material. Therefore, the 3-60B cask body material model is defined to be linear isotropic. It should also be noted that the purpose of the LS-DYNA analyses is to obtain the impact limiter

reaction. The cask material specification does not have any significant effect on the impact limiter reaction.

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.

RESPONSE:

ST-505 write-up has been revised to clearly describe the analyses performed. The specific comments are addressed below:

(1) The analyses have been performed by establishing the load deflection-curve for the cask and puncture bar geometry. This curve is used to establish the work-done versus deflection curve. The potential energy of the cask dropped from 40" height is balanced with the work-done curve. The cask stresses are calculated at this energy balance point. Thus, the analysis depicts the cask dropped on the puncture bar.

(2) It has been correctly pointed out that the symmetry about the horizontal plane implies an impact on the other end too. However, since the stresses resulting from the impact are highly local, based on St. Venant's principle, approximate boundary conditions on the horizontal plane will have little effects on the stresses at the point of impact. Symmetry boundary conditions on this plane, in fact will result in a conservative stress prediction. Please see Section 6.1 ST-505 for additional information.

(3) The analyses performed are quasi-static where the energy balance approach has been used to evaluate the maximum forces applied to the cask. The stresses are calculated based on these forces.

(4) The analysis for the puncture drop on the lid has been performed with the assumption that the bar strikes the part of the lid that will result in the maximum stresses. The largest stresses will occur when the impact takes place near the center of the lid. Consequently, the load corresponding to the flow stress of the rod material is applied as a pressure over an area that is approximately equal to the puncture bar cross-section area. It should be noted that the mild steel rod under such high loading will deform to the shape of the lid. Its cross-section will increase under pure compressive loading. Therefore, the load applied as pressure conservatively approximates the load transferred by the puncture bar.

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.

RESPONSE:

The statement in Section 2.7.1.5 refers to only the lead slump calculation. The lead slump in the casks may result from the shrinkage of the lead and/or compression of the lead column. To get the maximum bound of this slump, the conditions corresponding to the largest compressive loading and the most shrinkage have been considered for this evaluation.

The stress calculations during all the NCT and HAC events have been performed using the finite element models that utilize the temperature dependent material properties such as coefficient of thermal expansion and modulus of elasticity. The temperature distribution in the cask is obtained from the corresponding thermal analyses. Therefore, the relative expansion of the lead-shielding is accurately accounted for in all the analyses.

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.

RESPONSE:

The cask is intended for use a general purpose waste cask. The specific types of contents vary. The contents description, Section 1.2.2, is intended to provide limits for the critical characteristics of the contents to allow a demonstration of compliance.

For example, no specific isotopes are listed, indicating that any isotope is acceptable, as long as the quantity of activity does not exceed 3000 A_2, the fissile exempt limits of 10 CFR 71.15, or the decay heat limit of 500 watts.

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.

RESPONSE:

The 3-60B cask fire shield is connected to the cask body in such a way that it provides an air gap between the cask body and itself. During the hypothetical fire test, the air gap provides a thermal barrier which impedes the transfer of heat from the fire-shield to the cask. The transfer of heat from the fire source to the cask takes place by a combination of two phenomena - radiation and forced-convection. The total heat-flow rate to the cask is a function of resistance provided by the air gap and the equivalent resistance of the radiation heat transfer between the fire shield and the cask outer shell. A large resistance will reduce the heat transfer rate and it will take a long time for the fire-shield to attain the same temperature as the fire environment.

The finite element model of the 3-60B cask appropriately incorporates both these heat transfer phenomena. The air-mass resistance has been incorporated by temperature dependent conductivity and radiation heat transfer has been incorporated by the referenced text book formula (Holman; Reference 3-2 of the SAR). ES, therefore, believes that the temperature predicted by the finite element model, i.e. 1331°F is a reasonable result, which should be expected during the fire accident.

Please note that in the revised analysis this number has come down to 1331°F. In the revised analyses the inter-space emissivity between the fire-shield and the cask outer shell was increased from 0.15 to 0.45. This was done in order to conservatively transfer larger amount of heat to the cask body during the HAC fire accident. Please see TH-023 for the details of the revised analyses.

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.

RESPONSE:

The input and output files of the ANSYS FEM analyses are provided as attachment to TH-022 and TH-023. These documents are used as reference documents to the SAR. Additionally, the entire input, output, result and post-processing files, used in the thermal analyses, are being provided on a hard disk.

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.

RESPONSE:

For the HAC fire the foam of the impact limiters is conservatively assumed not to provide any thermal insulation. In the structural analyses of the HAC drop and puncture drop conditions, it has been shown that after these tests, the casing of the impact limiter will be intact and remain attached to the cask body. Therefore, it is assumed that the fire directly hits the two ends of the cask through the 1/2" plate that form the casing of the impact limiters, in addition to the entire length of the fire-shield. This explanation is added in Section 3.4 of the SAR.

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.

RESPONSE:

See the response to 3-4.

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.

RESPONSE:

The temperature contour plots during seven selected time instants have been provided in Figures 11 through 17 of TH-023. A representative figure has been included as Figure 3-

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.

RESPONSE:

The thickness of the air gap between the fire-shield and the cask body is maintained by the 5/32" diameter stainless steel wires (Item No. 9 of EnergySolutions Drawing No. C-002-165024-001). These wires are spot-welded to the cask. The fire-shield is placed on these wires and is welded to the cask outer shell around the two edges. Thus, except for the edges the fire-shield to cask-outer shell gap is equal to the diameter of the wires, i.e. 5/32".

The transfer of heat energy between the fire-shield and the cask takes place mainly by two phenomena, viz. conductance through the air mass, and radiation. The heat transfer rate by conduction thought the air mass is directly proportional to conductivity of air, and inversely proportional to the air gap thickness. The heat transfer by radiation between two concentric cylinders is governed by the classical equation:

$$q=\frac{\sigma A_1\left(T_1^4-T_2^4\right)}{\frac{1}{\varepsilon_1}+\frac{(A_1)(1/\varepsilon_2-1)}{A_2}}$$

See the TH-022 and TH-023 for the explanation of the terms. For two cylinders with small annular gap and made of similar materials, this equation reduces to:

$$q=\frac{\sigma\varepsilon A\left(T_1^4-T_2^4\right)}{2-\varepsilon}$$

It can be seen that the heat transfer rate is a function of the quantity ε/(2-ε). For two black bodies this quantity becomes unity but for two shiny metallic surfaces this quantity is rather small. The fire-shield is welded to the cask body in as-received shiny condition. After it has been welded to the cask, there is no real mechanism that could reduce the shine from these surfaces. An emissivity of 0.15 has been used for the two surfaces in the NCT analyses. However, for the HAC fire it is conservative to increase this number. The emissivity has been arbitrarily increased by a factor of 3, i.e. 0.45. The heat transfer rate between the fire-shield and the cask body is rather small and the 30-minute fire is able to raise the temperature of the cask body to the level shown by the analyses.

In the revised analyses, the cask body temperature has gone up to 353.5°F from earlier reported number of 263°F.

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.

RESPONSE:

The heat transfer coefficients for forced convection, based on Reynold's and Prandtl numbers, from other sources have also been calculated. They are included in Section 5.2 of TH-023. In the range of Raynold's and Prandtl number applicable to the 3-60B Cask, it has been shown that the heat transfer coefficient based on IAEA regulations Safety Series

No. 37 gives a slightly larger value. It should be noted that use of a larger heat transfer coefficient for forced convection will result in a conservative temperature prediction of the cask body. It is also observed from the results of the analyses that the major portion of the heat transfer during the fire takes place due to radiation, the forced convection heat transfer has a secondary effect on the results of the cask temperature during the fire transient.

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.

RESPONSE:

See the response to 3-8.

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.

RESPONSE:

The thermal analyses for NCT (TH-022) and HAC (TH-023) have been revised. The new analyses have been performed with two models each. In one model, the internal heat load is modeled implicitly by inputting the total heat as heat-flux on the cavity. In the second model, the internal content is explicitly modeled. It has been shown that the first model conservatively predicts the cask body temperature and the second one predicts the cask internal cavity and content temperature accurately but the cask body temperature predicted by this model is not conservative. Therefore, the results of the implicit models have been used for reporting the cask temperature and that of the explicit model have been used for reporting the cavity and internal content temperature.

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.

RESPONSE:

The text has been revised to correct the errors identified in issues 4-2 through 4-5.

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.

RESPONSE:
The calculation was corrected and the value of P_{a_N} changed to 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 3.19×10^{-6} cm^3/s. The value for L_{N_IH} should be 3.15×10^{-6} cm^3/s.

RESPONSE:
The calculation was corrected and the value for L_{N_IH} was changed to 3.15×10^{-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.

RESPONSE:
The calculation was corrected and the value for M_{mix} was changed to 11.75 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.

RESPONSE:
The calculation was corrected and H equals 14.32 minutes.

4-6 Provide justification for the value of 44,500 cm^2 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).

RESPONSE:
The surface area calculation has been added to the text with a different reference for the dimensions used.

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).

RESPONSE:

The void volume of a typical irradiated hardware shipment is shown to be 68% of the cask cavity volume in Example 1 of Attachment 3B to Section 3. For leak rate calculations, the void volume is conservatively assumed to be 25% of the cavity volume.

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).

RESPONSE:

The calculation has been revised. The revised calculation uses the assumption that the maximum cask activity of 3000 A_2 is contained in 100 g of powdered solids. With this assumption, the calculated reference leak rate ($L_{N\ PS}$) is greater than the reference leak rate for irradiated hardware. To ensure $L_{N\ PS}$ is not the minimum leak rate, the mass of powdered solids must be greater than 100 grams or the ratio of the activity of the powdered solids (in A_2) to the mass of the solids (in grams) must be less than 30.

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.

RESPONSE:

The hydrogen generation evaluation method and discussion text has been revised. The method and example calculations are contained in Chapter 3.

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.

RESPONSE:

The calculation of hydrogen generation has been revised and no longer uses RADCALC.

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.

RESPONSE:

The calculation of hydrogen generation has been revised and no longer uses RADCALC.

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.

RESPONSE:

The calculations of MNOP and hydrogen generation have been revised. The amount of hydrogen and oxygen resulting from radiolysis is described in the revised Section 3.3.2 along with the revised calculation of MNOP.

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 detail 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.

RESPONSE:

The calculation of hydrogen generation has been revised and is now based on the radiolysis of water that may remain in the cask after loading. The amount of hydrogen generated is based on the use of a bounding G value, which includes alpha, beta, and gamma radiation and assumes 100 % energy absorption in the contents. A typical secondary container is shown in Chapter 1 Figure 1-2. Examples of calculations of hydrogen generation for typical contents are provided in Chapter 3.

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.

RESPONSE:

The calculation of hydrogen generation has been revised and a method for ensuring the flammable gas concentration does not exceed 5% is included in Chapter 3 and in Chapter 7.

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."

RESPONSE:

The method for ensuring the flammable gas concentration does not exceed 5% is included in Chapter 7 as Attachment 1.

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.

RESPONSE:

Nitrogen inerting will not be used for ensuring the flammable gas concentration does not exceed 5% as discussed in the revised Chapter 3.

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.

RESPONSE:

Nitrogen inerting will not be used for ensuring the flammable gas concentration does not exceed 5% as discussed in the revised Chapter 3.

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.

RESPONSE:

Nitrogen inerting will not be used for ensuring the flammable gas concentration does not exceed 5% as discussed in the revised Chapter 3.

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.

RESPONSE:

Seal properties are provided in Chapter 4, Section 4.1.1.

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.

RESPONSE:

The thermal analysis has been revised. The seal temperature criteria are based on the calculated temperatures of the gas in the cask cavity under NCT (225°F) and HAC (320°F), which exceed the temperatures calculated for materials in the seal area. The temperature criteria for the seals are: minimum= -40°F, maximum= +250°F for extended use and +350°F for short durations (1 hour).

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

RESPONSE:

Point detector locations have been added to the model figures and the text includes a note that specific detector locations are given in the input files, which are provided.

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

RESPONSE:

The second of four radial surface detectors in SCALE has a default location of 1m from the cask surface. Since the cask surface for the 3-60B includes both the cask body in the middle section and the impact limiters at the ends, in order to determine the cask surface dose rate, the second surface detector was set at the radius of the impact limiter. Dose rates at the second surface detector represent the dose rates at the radial surface of the impact limiter. Dose rates at the first surface detector represent dose rates at the radial surface of the cask body.

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

RESPONSE:

Refinement of the model runs has eliminated large FSD results. When both point and surface detector results are obtained at the same location, the larger value is reported.

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

RESPONSE:

The SCALE SAS4 module in the simplified geometry option (IGO=0) used for modeling the 3-60B expects the radioactive source to be spent fuel with the fuel distributed uniformly around the cask midplane with fuel rod hardware at each end. The activity can be placed in the fuel or in the hardware with the input activity distributed over the entire source geometry, i.e., half the activity is placed in the top half of the cask model. The swarf HAC model has the swarf displaced and compressed to the end of the cask cavity as a result of the drop. To locate the activity at the end of the cask, the option was selected to place the radioactive source in the fuel hardware, with the hardware dimensions specified to match the assumed compressed shape. Since the input activity would be divided between both sets of "hardware", only half the input activity would placed in the swarf disk at the top of the cask. To properly represent the entire swarf activity at one end, the input activity was doubled. The resulting dose rates would represent the dose rates from the entire swarf source. The SAR text has been revised to clarify this.

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

RESPONSE:

The following table has been added to the SAR listing each SCALE model and details of its purpose.

TRANSPORT DIRECTION	CASK GEOMETRY	WASTE FORM	SECONDARY CONTAINER	DOSE LOCATIONS	FILE NAME
Radial	Cask Lid Half	Irradiated Hardware	Carbon Steel	Surface, 2m From Trailer	\HWtopRadialR2
Radial	Cask Bottom Half	Irradiated Hardware	Carbon Steel	Surface, 2m From Trailer	\HWbottomRadialR2
Axial	Cask Lid Half	Irradiated Hardware	Carbon Steel	Surface, 2m, 6m	\HWtopAxialR2
Axial	Cask Bottom Half	Irradiated Hardware	Carbon Steel	Surface, 2m, 6m	\HWbottomAxialR2
Radial	Cask Lid Half	Swarf	Polyethylene	Surface, 2m From Trailer	\SWtopRadialR2
Radial	Cask Bottom Half	Swarf	Polyethylene	Surface, 2m From Trailer	\SWbottomRadialR2
Axial	Cask Lid Half	Swarf	Polyethylene	Surface, 2m, 6m	\SWtopAxialR2
Axial	Cask Bottom Half	Swarf	Polyethylene	Surface, 2m, 6m	\SWbottomAxialR2

TRANSPORT DIRECTION	CASK GEOMETRY	WASTE FORM	SECONDARY CONTAINER	DOSE LOCATIONS	FILE NAME
Radial	Cask Lid Half	Irradiated Hardware	Carbon Steel	1m From Cask Surface	\HWtopRadialHACR2
Radial	Cask Bottom Half	Irradiated Hardware	Carbon Steel	1m From Cask Surface	\HWbottomRadialHACR2
Axial	Cask Lid Half	Irradiated Hardware	Carbon Steel	1m From Cask Surface	\HWtopAxialHACR2
Axial	Cask Bottom Half	Irradiated Hardware	Carbon Steel	1m From Cask Surface	\HWbottomAxialHACR2
Radial	Cask Lid Half	Swarf Disc	Polyethylene	1m From Cask Surface	\SWtopRadialHACR2
Radial	Cask Bottom Half	Swarf Disc	Polyethylene	1m From Cask Surface	\SWbottomRadialHACR2
Axial	Cask Lid Half	Swarf Disc	Polyethylene	1m From Cask Surface	\SWtopAxialHACR2
Axial	Cask Bottom Half	Swarf Disc	Polyethylene	1m From Cask Surface	\SWbottomAxialHACR2

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."

RESPONSE:

A procedure for determining a decay heat limit that will prevent an unacceptable hydrogen concentration has been added to Section 7.

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.

RESPONSE:

The sophisticated thermal analyses performed on the 3-60B are a more than adequate substitute for thermal testing. The materials of construction, i.e. stainless steel and lead, are not subject to a change in material properties due to aging that would affect heat transfer performance. Thus, no heat transfer testing is performed in the maintenance program.

B & S Machine Tool, Inc.
PO Box 1141
158 Old Wagener Rd.
Aiken, SC 29802
Phone: (803) 648-1826
Fax: (803) 642-5415

Quotation

Quote To: Energy Solutions
423 West 300 South Suite 200
Salt Lake City, UT 84101
United States

Quote Number:	14972			**Contact:**	Phillip Thomas
Quote Date:	06/29/09	**Expires:**	07/29/09	**Inquiry:**	
Customer:	ES			**Terms:**	Net 30 Days
Salesman:	Bart Blackwell			**Phone:**	(803) 758-1838
Ship Via:	Company vehicle			**FAX:**	(801) 321-0453
FOB:	Destination				

Thank you for the opportunity to submit this quote.

Item	Part Number / Description	Revision	Quantity	Price
1	C84-647-36 Rachet binder end - 3" ASTM 516 grade 70 steel plate - waterjet cut per print - profile only - material included Delivery: 2 - 3 weeks		32	$180.09 /EA
2	C84-647-36-C Rachet binder end - 3" ASTM 516 grade 70 steel plate - waterjet cut profile and machined complete per print (16 of each end configuration) - material included Delivery: 2 - 3 weeks		32	$217.38 /EA
3	C84-647-36.1 Shaft per C84-647 item 36.1 - material included Material - AISI 4140 HT round bar - meets ASTM A320-L7 tensile and yield requirements Delivery: 2 weeks		16	$88.36 /EA
			Total:	***$14,132.80***

By Bart T Blackwell
B & S Machine Tool, Inc.

ENERGYSOLUTIONS

AFFIDAVIT
SUBMITTED BY ENERGYSOLUTIONS
CONCERNING CONFIDENTIAL INFORMATION AND TRADE SECRETS

STATE OF SOUTH CAROLINA]
] *ss.*
COUNTY OF LEXINGTON]

I, Mirza Baig, depose and say that I am duly authorized to make this affidavit, and have reviewed or caused to have reviewed the information which is identified below as proprietary. The following documents and corresponding data files, which are included with our submittal letter E&L-065-09, Safety Analysis Report for the 3-60B Package contains proprietary information that should be withheld from public disclosure:

Attachment 3: Proprietary References, which contains the following proprietary documents and corresponding data files:

ST-551, Rev.2: Validation of the LS-DYNA Drop Analyses Results with the Test Data
ST-557, Rev.1: Drop Analysis of the 3-60B Cask Using the LS-DYNA Program
ST-596, Rev.0: 3-60B Cask ANSYS/LS-DYNA Model Sensitivity Analyses

I have personal knowledge of the criteria and procedures utilized by Energy*Solutions* in designating information as a trade secret or as confidential information of a commercial or financial nature. These calculations contain unique information and methods that have been developed by the Energy*Solutions'* staff for the evaluation of transportation packagings. These methods are considered confidential information that includes Company trade secrets incorporated into such evaluation processes. The proprietary information submitted to the Commission contains the type of information Energy*Solutions* regards as protected and of the type not to be disclosed to unauthorized persons.

The information designated here as proprietary is not available from public sources. Public disclosure of this information would cause substantial harm to the competitive position of Energy*Solutions*. The Company has made substantial investments in salaries and capital equipment and has committed to refine and improve Energy*Solutions*' radioactive waste management system. Competitors of Energy*Solutions* would have great difficulty in duplicating the methods developed by Energy*Solutions*, due not only to the financial investment of Energy*Solutions*, but also to the unique skills, talents, and expertise of Energy*Solutions* employees who have developed these concepts. Disclosure of this information could cause Energy*Solutions* to lose the financial opportunity and business associated with this and other projects similar in nature.

Mirza I. Baig
Technical Services Manager, Engineering & Licensing

STATE OF SOUTH CAROLINA]
] *ss.*
COUNTY OF LEXINGTON]

On this 30th day of June 2009, before me, a Notary Public in and for the State of South Carolina, duly commissioned and sworn, personally appeared Mirza Baig, Technical Services Manager, Engineering & Licensing for Energy*Solutions*, and on oath stated that he was authorized to make this affidavit on behalf of the corporation.

IN WITNESS WHEREOF, I have set my hand and affixed my official seal the day and year first above written.

Notary Public, State of South Carolina

My Commission Expires July 30, 2010

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