71-9204

ENERGYSOLUTIONS

May 1, 2009
E&L-052-09

Michele M. Sampson, Senior Project Manager
Licensing Section
Division of Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Ms. Sampson:

Subject: Response to SECOND ROUND REQUEST FOR ADDITIONAL INFORMATION FOR REVIEW OF THE MODEL NO. 10-160B (Docket No. 71-9204 TAC No. L24162)

Energy*Solutions* provides a response to the 2nd request for additional information dated February 25, 2009, i.e., Attachment 1. As noted in Attachment 1, responding to the questions required revision to portions of the SAR. Those revised Chapters are listed below as Attachment 2. The DVD containing the data requested in the RAI is Attachment 3.

The three attachments to this letter are listed below:

Attachment 1 Response to the request, the NRC questions are followed by our response.

Attachment 2 Revised SAR Chapters; please replace the previously provided Chapters with the Chapters in this attachment. Chapters included are: Chapter 1, Chapter 3, Chapter 4 , Chapter 4 Appendix 4.10.2, Chapter 5, and Chapter 7.

Attachment 3 DVD containing thermal data

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

Sincerely,

[signature]

Mirza I. Baig
Technical Services Manager – Engineering & Licensing

Attachments: As stated

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Attachment 1

3-0 THERMAL EVALUATION

3-1 *(a) Explain the calculation, in detail, for the maximum fire shield temperature (1361' F) as reported in Table 3-4 as a result of the cask being exposed to a fire with an average environmental temperature of 1475' F for the thermal analysis of the 10-1 60B package.*

(b) Provide the ANSYS input files for NCT and HAC analyses for confirmatory analysis.

This information is required to show compliance with 10 CFR 71.71 and 71 -73.

RESPONSE

(a) The 10-160B 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 10-160B 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 text book formula (Equation 3, SAR page 3-9). ES, therefore, believes that the temperature predicted by the finite element model, i.e. 1361°F is a reasonable result, which should be expected during the fire accident.

(b) The input and output files for both 1-d finite element NCT and HAC analyses and the supplemental 2-d finite element analyses are being provided with this response on a DVD. The electronic data also includes the result files and database files that could be used with ANSYS 11.0 software package to review the results in any fashion that is convenient to the reviewer.

3-2 *Provide the dimension of the air gap between the fire-shield and the cask body. Also explain the effect of the air gap on heat transfer characteristics of the 10-160B, particularly during the HAC.*

Figures 1-1 and 3.1 indicate the existence of an air gap between the fire shield and the outer shell of the 10-1 60B cask body. EnergySolutions drawing, C110-D-29003-010, Cask Assembly General Notes/Parts List, does not quantify the air gap between fire shield and the outer shell of the cask. In light of significant temperature drop from the fire-shield to outer shell temperature (1361' F to 249' F), the staff needs to know the gap size and its effect on heat transfer in the thermal model.

This information is required to show compliance with 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 helically wound 5/32" diameter stainless steel wires (Item No. 8 of EnergySolutions Drawing No. C-100-D-29003-010). These wires are wrapped around the cask outer shell at 12" pitch and spot welded every 24" as shown on Sheet 4 of the drawing. 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 (Equation 4, SAR page 3-9):

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

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 e/(2-e). 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 the 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 analyses. Therefore, the heat transfer rate between the fire-shield and the cask body is rather small and the 30-minute fire is only able to raise the temperature of the cask body to the level shown by the analyses.
It should be noted that the supplemental analyses included with this RAI as Attachment 1 also support the results of the SAR analyses.

3-3 *Provide assurance with supporting calculations that the accuracy of seal temperature is not compromised due to the fact that the seal is not explicitly modeled in the hypothetical accident thermal evaluation.*

Section 3.5.3 of SAR indicates that "The cask seals are not explicitly modeled. However, the maximum seal temperature is conservatively set equal to the maximum calculated temperature of the cask body, 25Z°F. However, the maximum seal temperature will not exceed the maximum temperature of the cask body, 252" F. Thus, the seal temperature is conservatively set equal to the maximum calculated temperature of the cask body plus 100" F for an analyzed maximum of 352' F."

Explain how the licensee concludes that the maximum seal temperature during HAC fire will not exceed the maximum temperature of the cask body.

This information is required to show compliance with 10 CFR 71.33 and 71.73.

RESPONSE

The seal has not been explicitly modeled in the original SAR thermal analyses. A conservative assumption on the seal temperature was made. In order to obtain the seal temperature explicitly, and to obtain the waste temperature during the NCT and HAC fire, supplemental analyses, using a 2-dimensional finite element model, have been performed. The results of these analyses are included in Chapter 3 of the SAR. The analyses show that the seal temperatures reported in the SAR are, indeed, conservative. The analyses are provided as Attachment 1 to these responses and included as a reference in the SAR. The input and output data of the analyses are included with this RAI in electronic form on a DVD.

3-4 *Explain and justify the thermal boundary condition on the inside surface of the cask.*

In the modeling of internal heat loading, the applicant converted the heat source term into a heat flux boundary condition. This assumption bypasses the calculation of temperature of material contents (cargo) within the cask cavity. With this assumption, the temperature of the cavity content is presumed to be higher than the shell. However, in SAR Sections 3.4.4 and 3.5.4 for Maximum Internal Pressures sections, 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 to show compliance with 10 CFR 71.33 and 71.73.

RESPONSE

The original SAR analysis did not include the internal heat loading. It used a constant heat flux on the cavity surface to represent the internal heat load. In order to respond to the request for the temperature of the waste content during the NCT and HAC fire, supplemental analyses, using a 2-dimensional finite element model, have been performed. The results of these analyses are included in Chapter 3 of the SAR. The analyses are provided as Attachment 1 to these responses and included as a reference in the SAR. The input and output data of the analyses are included with this RAI in electronic form on a DVD.

The results of the analyses show that because of the modified boundary conditions representing the internal heat load, there is slight increase in the cask component temperatures and temperature gradients. Table 3-1 that lists the thermal analyses results has been updated. It is shown that the updated results are still within the bounds of the conservative temperature and temperature gradients used in the structural analyses. Therefore, no structural analyses need to be updated. The increase in the bulk air temperature due to modified boundary conditions has been incorporated in calculating the MNOP and design pressures in Chapter 3. The containment calculations in Chapter 4 have also been updated due to these changes.

4-0 CONTAINMENT

4-1 *Provide helium permeability of the chosen elastomeric seals as a function of operating temperature. Provide a comprehensive leak test plan, considering the helium permeation, to demonstrate the compliance of allowable leakage rate analyzed in containment analysis.*

The licensee indicated that using a He leak test could achieve a more conservative leak rate of 1.0e-7 atm-cm3/sec. In light of high helium permeability through elastomers, the measured actual leakage rate could possibly include the helium permeation rate in certain conditions. The helium permeation effects could generate errors in leak test measurement.

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

RESPONSE

Section 4.9, the helium leak test method, has been revised to include the following: This test method is only applicable to a 10-160B cask with butyl rubber o-rings and ethylene propylene seals.

4-2 *Explain the scenarios in Criteria ii) in SAR Section 4.8 and justify using inerting method to ensure safe shipment of vessels which generate combustible gas.*

The criterion states "the secondary container and the cask cavity (if required) must be inerted with a diluent to assure the oxygen, including that radiolytically generated, shall be limited to 5% by volume in those portions of the package which could have hydrogen greater than 5%. Based on the methodology in Appendix 4.10.2, the intent of the gas generation methodology is to limit *the hydrogen generation under 5%." Criterion ii) shows potential scenarios that are inconsistent with the gas generation methodology. The applicant needs to explain the scenarios of hydrogen concentration greater than 5% and justify the inconsistency. In addition, the licensee needs to describe the detailed procedure and methodology to demonstrate that the inerting procedure limits the oxygen content to below 5% and justify the mixture is nonflammable.*

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

RESPONSE

Criterion ii was not intended to apply to TRU wastes, which are governed by the requirements of Appendix 4.10.2, assuring that the hydrogen concentration is below 5%. To eliminate the unintended inconsistency, Criterion ii is revised to:

ii) The secondary container and the cask cavity (if required) must be inerted with a diluent to assure the oxygen, including that radiolytically generated, shall be limited to 5% by volume in those portions of the package which could have hydrogen greater than 5%. This criterion does not apply to TRU wastes, which shall be governed by the requirements of Appendix 4.10.2.

4-3 *Describe specific parts of the sub-tier appendices to be under payload engineer control in the amendment request.*

According to the response licensee provided, the applicant requests the site specific sub-tier appendices (4.10.2.1 to 4.10.2.5) to be evaluated and maintained by payload engineer without NRC approval. Currently, the site specific appendices (4.10.2.1 to 4.10.2.5) include content codes and detailed methodologies which demonstrate the compliance to Appendix 4.10.2. These compliance methodologies contain detailed data and calculations' which are not elaborated in' the main appendix 4.10.2. These methodologies are important for staff to evaluate package compliance.

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

RESPONSE

The current need for the requested change does not have high priority. In order to avoid a delay in obtaining approval of the other changes, the changes involving the payload engineer have been deleted from Appendix 4.10.2. In the future, this change may be re-requested and will include the additional detail needed by the staff to evaluate package compliance.

5-0 *SHIELDING EVALUATION*

5-1 *The staff needs additional clarifying information on the shipment of neutron sources.*

Based on the analyses in the SAR, the staff plans to place restrictions on the shipment of neutron sources. Confirm that these details are adequate to meet your shipping requirements, alternatively, provide additional analytical information supporting shipment of additional sources.

The first part of CoC Paragraph 5.(b) (2) will be revised to read:

Maximum quantity of material per package

Type B quantity of radioactive material, not to exceed 3,000 times a Type A quantity for gamma emitting materials.

The only neutron sources permitted for shipment are special form Pu239-Be sources that must meet the requirements of 10 CFR 71.75 and have a maximum emission rate of 2.8E+7 n/sec.

For any combination of nuclides present a sum of "partial fractions" must be less than or equal to one.

Gamma and neutron emitting sources may be shipped together as long as the sum of "partial fractions" is less than 1.

$$\sum_{i=1}^{n} \frac{a_i}{A_{GN_i}} \leq 1$$

Where for a particular payload mix, a_i is the actual activity of source "i" and A_{GN} is the limiting activity of source "i."

This information is needed to satisfy the requirements of 71.33(b).

RESPONSE

EnergySolutions has the following questions concerning the proposed CoC language:

1. By "first part of CoC Paragraph 5. (b) (2)", do you mean the first sentence, "Type B quantity of radioactive material, not to exceed 3,000 times a Type A quantity."?
2. Since the revision specifies a special form source, should special form radioactive material be added to 5. (b) (1)?
3. If we wanted to include additional sources, what additional analytical information is needed?
4. A ^{239}Pu-Be source with an emission rate of 2.8E+7 n/sec will produce a dose rate at 2m of approximately 2.4 mrem/hr. Why is the source limited to this emission rate?
5. How is the activity limit of the neutron source determined?

Answers were provided in a teleconference to discuss the shielding analysis. EnergySolutions agrees with the proposed conditions with the change to the maximum neutron emission rate as discussed in the teleconference.

5-2 *Please provide additional details on the methods of compliance and verification in Appendix 4.10.2.*

The staff understands that dose rate measurements will be made for the 10-160B payload since the contents cannot always be known with full certainty. Identify where, or include in Appendix 4.10.2 the details, including the quality assurance program, of how these dose rate measurements will be made. Identify where, or include the limits (200 mrem/hr at the surface, and 10 mrem/hr at 2 meters) in Appendix 4.10.2.

This information is needed to determine compliance with 10 CFR 71.47.

RESPONSE

Since Appendix 4.10.2 only applies to TRU waste, we suggest that requirements for the operation of the package be contained in Section 7, Operating Procedure. The current language is revised to:

7.1.18 Prior to shipment of a loaded package the following shall be confirmed:

(a) That the licensee who expects to receive the package containing materials in excess of Type A quantities specified in 10 CFR 20.1906(b) meets and follows the requirements of 10 CFR 20.1906 as applicable.

(b) That trailer placarding and cask labeling meet DOT specifications (49 CRF 172).

(c) That the external radiation dose rates of the 10-160B are less than or equal to 200 millirem per hour (mrem/hr) at the surface and less than or equal to 10 mrem/hr at 2 meters in accordance with 10 CFR 71.47.

(d) That all anti-tamper seals are properly installed.

The user of the package is required by 10 CFR 71.17 to have an NRC approved quality assurance program. The QA program applies to all aspects of use of the package, including performance of dose rate measurements.

5-3 *Add the actual FGE factors from the RH-TRAMPAC document to Appendix 4.10.2.*

This information is needed to satisfy the requirements of 71.33(b).

RESPONSE

The following table will be added to Appendix 4.10.2 following step 9.1.3.

Table 9.1.3 – Pu-239 Fissile Gram Equivalent, U-235 Fissile Equivalent Mass, Decay Heat, and Specific Activity of Radionuclides With FGE >0

NUCLIDE	SPECIFIC ATOMIC NUMBER	Pu-239 FGE[1,2]	U-235 FEM[1,2,3]	DECAY HEAT[4] (W/g)	SPECIFIC ACTIVITY[5] (Ci/g)
U-233	92	9.00E-01	1.80E+00	2.84E-04	9.76E-03
U-235	92	6.43E-01	1.00E+00	6.04E-08	2.19E-06
Np-237	93	1.50E-02	3.00E-02	2.09E-05	7.13E-04

Pu-238	94	1.13E-01	2.25E-01	5.73E-01	1.73E+01
Pu-239	94	1.00E+00	2.00E+00	1.95E-03	6.29E-02
Pu-240	94	2.25E-02	4.50E-02	7.16E-03	2.30E-01
Pu-241	94	2.25E+00	4.50E+00	3.31E-03	1.04E+02
Pu-242	94	7.50E-03	1.50E-02	1.17E-04	3.97E-03
Am-241	95	1.87E-02	3.75E-02	1.16E-01	3.47E+00
Am-242m	95	3.46E+01	6.92E+01	4.32E-03	9.83E+00
Am-243	95	1.29E-02	2.57E-02	6.49E-03	2.02E-01
Cm-243	96	5.00E+00	1.00E+01	1.90E+00	5.22E+01
Cm-244	96	9.00E-02	1.80E-01	2.86E+00	8.18E+01
Cm-245	96	1.50E+01	3.00E+01	5.77E-03	1.74E-01
Cm-247	96	5.00E-01	1.00E+00	2.98E-06	9.38E-05
Cf-249	98	4.50E+01	9.00E+01	1.54E-01	4.14E+00
Cf-251	98	9.00E+01	1.80E+02	5.89E-02	1.60E+00

1 American National Standards Institute/American Nuclear Society (ANSI/ANS), 1981, "Nuclear Criticality Control of Special Actinide Elements," ANSI/ANS-8.15-1981, American National Standards Institute/American Nuclear Society, Washington, D.C.
2 American National Standards Institute/American Nuclear Society (ANSI/ANS), 1998, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," ANSI/ANS-8.1-1998, American National Standards Institute/American Nuclear Society, Washington, D.C.
3 American National Standards Institute/American Nuclear Society (ANSI/ANS), 1987, "Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors," ANSI/ANS-8.12-1987, American National Standards Institute/American Nuclear Society, Washington, D.C.
4 International Commission on Radiological Protection, 1983. International Commission on Radiological Protection, 1983, "Radionuclide Transformations: Energy and Intensity of Emissions," Annals of the International Commission on Radiological Protection-38, Volumes 11-13, Pergamon Press, Oxford.
5 Walker, F.W., Kiravac, G.J., and Rourke, F.M., 1983, Chart of the Nuclides, 13th Edition, Knolls Atomic Power Laboratories, Schenectady, NY.
Ci/g = Curies per gram.
W/g = Watts per gram.