October 26, 2010

Mr. Mirza I. Baig
Technical Services Manager
Engineering & Licensing
Energy*Solutions*
140 Stoneridge Drive
Columbia, SC 29210

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE MODEL NO. 10-160B PACKAGE

Dear Mr. Baig:

By letter dated April 2, 2010, and supplemented May 20, 2010, Energy*Solutions*, submitted an amendment request to add powdered solids to the list of approved contents of the Model No. 10-160B package. By letter dated September 27, 2010, Energy*Solutions* provided responses to a first Request for Additional Information, dated July 12, 2010, and also submitted Revision No. 2 of the package application.

The staff has determined that further information is needed to complete its technical review. The information requested is listed in the enclosure to this letter. We request that you provide this information by December 13, 2010. If you are unable to meet this deadline, you must notify us in writing no later than November 30, 2010, of your new submittal date and the reasons for the delay. The staff will then assess the impact of the new submittal date and notify you of a revised schedule.

Please reference Docket No. 71-9204 and TAC No. L24435 in future correspondence related to this request. The staff is available to meet to discuss your proposed responses. If you have any questions regarding this matter, I may be contacted at (301) 492-3408.

Sincerely,

/RA/
Pierre M. Saverot, Project Manager
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9204
TAC No. L24435

Enclosure: Request for Additional Information

October 26, 2010

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Technical Services Manager
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Docket No. 71-9204
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Enclosure: Request for Additional Information

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Request for Additional Information
Energy*Solutions*
Docket No. 71-9204
Model 10-160B Shipping Cask

By letter dated September 27, 2010, Energy*Solutions* submitted Revision No. 2 of the Model No. 10-160B package application and its responses to a first request for additional information (RAI) dated July 12, 2010.

This second RAI identifies information needed by the U.S. Nuclear Regulatory Commission staff (the staff) in connection with its review of the package application. The requested information is listed by chapter number and title in the package application.

Each individual RAI describes information needed by the staff to complete its review of the Model No. 10-160B package application and to confirm whether the applicant has demonstrated compliance with regulatory requirements.

Chapter 5 - Shielding Evaluation

RAI 5-1 Demonstrate it is appropriate to reduce the SAS4 calculated dose rates by a factor of two for the Model No. 10-160B package shielding analysis.

In its response to RAI 5-1, the applicant states: "In fact, the validation report for SAS4 (NUREG/CR-6484) states that 'gamma-ray dose-rate calculations with major contributions due to active fuel show over a factor of 2 over prediction of the measured quantities.'" The staff reviewed, in particular, Chapter 4 of NUREG/CR-6484, which shows that SAS4 does not always over predict the dose rates by a factor of 2. The staff's review of the validation cases presented in NUREG/CR-6484 indicates that SAS4 actually underestimates dose rates for simple geometries as presented in Table 28. In fact, Table 28 indicates that the SAS4 model predicts dose rates fairly accurately for well-defined gamma and neutron sources; most results show underestimates are within 6 to 8 percent accuracy. Table 28 also shows that the thicker the shielding, the bigger the underestimate is for up to a 25 cm iron slab. Even in Table 29, there is a case (i.e., VSC (58.2)) that shows that SAS4 underestimated the dose rate by a factor of almost 3.

In addition, review of NUREG/CR-6484 indicates that the statement quoted by the applicant is for a special case of a spent fuel cask. The large errors in the calculated dose rates presented in Section 4 of NUREG/CR-6484 appear to be related to the spent fuel section of the casks. As such, the large errors in the dose rates may have been introduced by a variety of factors, including propagations of errors in the source term calculations of the spent fuels, inaccuracy in the fuel depletion data, simplifications of the geometry in the fuel depletion model, errors in the cross section data, and errors in cask modeling. In fact, as stated in NUREG/CR-6484, the developer was not quite sure what the causes of the errors were. It is the staff's position that these errors are not representative of the errors likely for the Model No. 10-160B package.

The staff also reviewed the SAS4 manual. The SAS4 manual states: "The primary function of the Shielding Analysis Sequence No. 4 (SAS4) control module is to perform a three-dimensional (3-D) Monte Carlo shielding analysis of a nuclear fuel transport or storage cask

using an automated biasing procedure." The primary targeted application of the SAS4 is for spent fuel storage and transportation package shielding calculations. As such, the fact that SAS4 over predicts dose rates for some casks cannot be used as a basis for adjusting the results by a factor of two. The fact that the large errors in the calculated dose rates presented in Section 4 of NUREG/CR-6484 appear to be related to spent fuel in the casks show that these results may not be applicable to the Model No. 10-160B package. The applicant needs to either demonstrate that decreasing the calculated dose rates by a factor of two in the revised SAR is appropriate or revise the graphs for Maximum Activity for Point and Unit Density Distributed Sources in the revised SAR. Benchmarks of the SAS4 to the Model No. 10-160B package dose rate measurements might be an acceptable approach for validating the code for the Model No. 10-160B package design.

In addition, reducing the calculated dose rates by a factor of two causes a self-inconsistency in the application. The staff used 13.4 Ci of Co-60 as a sample problem to check how this methodology works. The results seem to indicate that the data found from these curves produced 200% of the allowable content.

Based on the information provided in page 5-2 of the application and the examples in Attachment 1 of the application, the maximum allowable Co-60 source is 13.4 Ci. Since Co-60 gives two photons, 1.17 MeV and 1.33 MeV, per decay, the total number of photons from the 13.4 Ci source is 4.96×10^{11} ($13.4 \times 3.7 \times 10^{10}$) for each energy group. From the curve in Attachment 1 of the application, the corresponding maximum radiations from these two gammas are 2.98×10^{12} γ/s and 1.7×10^{12} γ/s, respectively. Thus, the fractions of the 13.4 Ci of Co-60 for the two photons in these two energy group are:

$$4.96 \times 10^{11}/(2.98 \times 10^{12}) = 0.166, \text{ and}$$

$$4.96 \times 10^{11}/(1.7 \times 10^{12}) = 0.292, \text{ respectively.}$$

The total fractional radiation source is 0.458. From page 5-2, it is understood that 13.4 Ci of Co-60 is the source loading limit for the packaging design; based on the description of the methodology, the fraction of the total source load should be very close to 1.0 rather than 0.458. Therefore, using the methodology and the curves in Chapter 7 to determine the maximum Co-60 source that can be shipped will exceed the design basis source described in Section 5.2.2 of the application.

This information is needed for the staff to determine if the Model No. 10-160B package meets the regulatory requirements of 10 CFR 71.47 and 71.51.

RAI 5-2 Demonstrate that using z=40 as the material of the content produces conservative results for gamma sources in all energy ranges.

Section 5.5 of the application states: "The material of the source was selected as Zr (z=40); multiple calculations with various materials showed a material selection of Zr was conservative." Provide the information used to determine that z=40 is the most conservative content for the dose calculations.

Be sure to include what energy range of the photons was used in this study for gamma radiation and explain why this result is appropriate for gammas in both high and low energy ranges because the gamma attenuation through materials is highly dependent on the energy of the particles.

This information is needed for the staff to determine if the Model No. 10-160B package meets the regulatory requirements of 10 CFR 71.47 and 71.51.

RAI 5-3 Justify the use of the Density Correction Factor (DCF) for gammas with energy other than 0.9 MeV.

The equation for the DCF was determined using 0.9 MeV gammas. The staff believes that gammas of higher or lower energy would have different attenuation through varying density material. A higher percentage of lower energy gammas would tend to be stopped than the higher energy gammas. Therefore the staff does not find that the DCF equation would necessarily be applicable or bounding for gammas of other energy. Justify that this equation is applicable or bounding for gammas of all energies that are to be stored in the Model No. 10-160B package.

The application also states that the geometry was changed when performing these density studies. Provide additional information on how exactly the geometry has been changed.

This information is needed to determine if the Model No. 10-160B package meets the requirements of 10 CFR 71.47 and 71.51.

Chapter 7 – Operating Procedures

RAI 7-1 Revise the 3rd paragraph of page 7-1 of the application to make the maximum activity as the dominating restriction of the package content.

On page 7-1 of the application, Revision No. 2, the applicant states: “The maximum permissible activity is 3000 A2 or the maximum activity in gammas/sec, determined per Attachment 1, whichever is less.” Since the maximum activity is the primary control for the payload, the applicant is requested to revise the operating procedures to clearly indicate content limit is controlled by the quantity of radioactive materials. The use of A_2 as the restriction to the quantity of the contents was intended for LSA packages based on the regulations prior to 2004.

The applicant is requested to provide this information. This information is needed for the staff to determine if the Model No. 10-160B package meets the regulatory requirements of 10 CFR 71.47 and 71.51.

RAI 7-2 Add a procedure to measure and determine the TI (Transport Index) in the step prior to shipment measurement.

Chapter 7 of the application, Revision No. 2, describes the operating procedures for the Model No. 10-160B package. However, the measurement and calculation of the TI

requirements were not presented in the operating procedures.

The applicant is requested to modify the application to add this important task in the operating procedure.

This information is needed for the staff to determine if the Model No. 10-160B package meets the regulatory requirements of 10 CFR 71.47.

RAI 7-3 Provide a limit for maximum energy and percentage of emissions.

Step 4 in Attachment 1 to Chapter 7 currently states that any photons with energies above 2.5 MeV should be placed in the highest energy group (2.0-2.5MeV). The staff understands that this is intended to cover certain nuclides that may have a very low percentage high energy gamma emission.

However, the current analyses and Certificate of Compliance, if approved as is, do not prohibit an entire source of high energy gammas (above 2.5 MeV) to be shipped. Therefore, the staff requests that the applicant create an upper limit of either energy, or percentage of emissions, or some combination of both that would be reasonably bounded by the analysis. The applicant should justify their limit.

This information is needed to determine if the Model No. 10-160B package meets the requirements of 10 CFR 71.47 and 71.51.

RAI 7-4 Revise the methodology for step 5 in Attachment 1 to Chapter 7 of the application to use the maximum energy instead of the mid-point energy of each photon energy group.

Using the mid-point for each photon energy group may substantially underestimate the actual dose rate, especially for the high photon energy groups. For example, the delta E (from mid-point to upper limit) is 0.25 MeV for the energy group of 2.0 – 2.5 MeV which is greater than the total energy ranges of the typical energy groups (as stated for step 4 in Attachment 1) of 0.3-0.4, 0.4-0.6, 0.6-0.8, and 0.8-1.0 MeV. The staff believes that neglecting such a large energy range for the higher photon energy groups may lead to reduced conservatism in the dose rate calculations.

This information is needed to determine that the 10-160B package meets the requirements of 10 CFR 71.47 and 71.51.

RAI 7-5 Revise the methodology for step 6 in Attachment 1 to Chapter 7 of the revised application to explain how the Density Correction Factor (DCF) will be calculated in the source density is less than 1 or greater than 8 g/cc.

The equation for DCF used in step 6 is based on a curve fit for calculations performed in Table 5.8 for the DCF as a function of the source density. However, the minimum and maximum density used in these calculations was 1 and 8 g/cc, respectively.

Explain how DCF will be used in this methodology for source densities less than 1 and greater than 8 g/cc.

This information is needed to determine if the Model No. 10-160B package meets the requirements of 10 CFR 71.47 and 71.51.