Department of Energy
Washington, DC 20585

September 15, 2013

Attention: Document Control Desk
Jose R. Cuadrado
Project Manager
Licensing Branch
Division of Spent Fuel Storage and Transportation,
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Jose Cuadrado:

The Department of Energy Packaging Certification Program (DOE PCP) hereby submits Revision 10 of the Safety Analysis Report (SAR) for the ATR Fresh Fuel Shipping Container (ATR FFSC) package, USNRC Docket No. 71-9330, TAC No. L24709, addressing NRC RAI's dated June 21, 2013.

Changes included in Revision 10 of the SAR provide further clarification concerning air thermal conductivity and clarify certain assumptions made concerning temperature distribution and enhanced heat transfer.

The attachment (4 pages) to this letter summarizes the changes made to the SAR in Revision 10.

Electronic copies of this letter have been sent to you and Branch Chief Michelle Sampson. Please provide a copy of this letter to NRC Document Control.

If you have any questions or need more details please call at 301-903-5513 or james.shuler@em.doe.gov.

James M. Shuler

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Docket No. 71-9330, Model No. ATR FFSC Package
Changes Included in Revision 10 of the SAR

Responses to NRC RAIs on Revision 9 of the SAR:

3-1 Clarify why the air thermal conductivity is not calculated using the curve fits provided in Table 3.2-4 of the SAR.

SAR page 3-7 states that because the thermal conductivity of air varies significantly with temperature, the computer model calculates the thermal conductivity across air spaces as a function of the mean film temperature. If the temperature is known at the node or cell location, the curve fits or other reliable air property tables should be used instead. Otherwise, the applicant should explain why using the mean film temperature will result in realistic air thermal conductivity values.

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

> ***Response:*** The SAR text has been misinterpreted. The Table 3.2-4 data, which lists the thermal conductivity of air as a function of temperature, is used to compute the conductance across the air gaps. Since the air volume in narrow gaps is not specifically modeled, the proper temperature to use in determining the temperature dependent thermal conductivity of the air in the gap (i.e., the air 'film') is the mean temperature of the surfaces on either side of the gap. This mean 'film' temperature is then used with the Table 3.2-4 temperature dependent properties to determine the thermal conductivity of the air in the gap. The SAR text in Section 3.2.1 has been modified to clarify this point.

3-2 Clarify why for fire initial condition a uniform temperature distribution of 100°F based on a zero decay heat package at steady-state conditions with a 100°F ambient with no insolation is assumed.

SAR page 3-20 states that, for a fire initial condition, the applicant assumes an initial, uniform temperature distribution of 100°F based on a zero decay heat package at steady-state conditions with a 100°F ambient and no insolation. The SAR also states that this assumption complies with the requirement of 10 CFR 71.73(b) and NUREG-1609. Assuming this initial condition is unrealistic because the initial temperature distribution will be a function of the ambient temperature and insolation, the initial package temperatures at the start of the fire will be higher than 100°F due to solar heating.

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

> ***Response:*** The initial test conditions specified in 10 CFR 71.73(b) address only the ambient temperature and is silent on the level of insolation. The NRC has adopted the view that the effects of insolation may be ignored prior to and during the fire: "*NRC adopts the view of the thermal experts who participated in developing the IAEA regulations. Those experts thought the effects of solar radiation may be neglected before and during the thermal test but that such effects should be considered in the subsequent evaluation of the package response.*" (Federal Register, Vol. 60, No. 188, Thursday, September 28, 1995, Section 71.73). Paragraph 3.5.5.1 of NUREG-1609 reflects this position by stating that the

Initial conditions for HAC is "An ambient temperature between -29°C (-20°F) and 38°C (100°F) with no insolation." Therefore, the initial condition evaluated in the SAR is in compliance with both 10 CFR 71 and NUREG-1609. Insolation is considered for the post-fire thermal response of the package.

The appropriateness of the assumed starting condition is further supported by the low thermal mass of the package which minimizes the HAC impact of higher initial component temperatures due to insolation. As seen from Table 3.3-1, consideration of the maximum insolation loading raises the package component temperatures by approximately 50°F above the initial 100°F level assumed by the HAC evaluation. The thermal response curves presented in Figure 3.4-1 demonstrates that the fire condition recovers this 50°F temperature difference for the outer components within the first few seconds of fire exposure. Further, since all package components exhibit thermal margins greater than 50°F as shown in Table 3.4-1, the inclusion of insolation effects prior to the fire event would not have impacted the safety basis for the design.

Section 3.4.3.1 of the SAR has been modified to include the above discussion of insolation effects in the subsequent evaluation of the safety basis for the design, as recommended by the NRC and IAEA. A similar modification has been made to Section 3.6.8.3.1.

3-3 Clarify how it is determined that increasing the thermal conductivity associated with the air overpack nodes in the lower quadrant of the package by a factor of 2 from that for conduction would properly capture the enhanced heat transfer that convection would cause in this region.

SAR page 3-32 states that the thermal conductivity associated with the air overpack nodes in the lower quadrant of the package are increased by a factor of 2 from that for conduction as a means of simulating the type of enhanced heat transfer that convection would cause. However, there is no explanation on how this factor is determined. Also the application does not state if the increased values will result in realistic heat transfer characteristics in this region.

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

Response: This question was previously raised and addressed in RAI 3-4 under Docket No. 71-9330, TAC No. L24105, dated January 25, 2008. As explained in that RAI response, the factor of 2 was an estimate of the enhanced heat transfer that convection would cause in the lower quadrant. However, since subsequent examination of the temperature distribution at the end of the fire event showed no discernible difference in the insulation jacket temperature between the upper and lower quadrants, it was concluded that the heat transfer within these cavities was dominated by radiation and the potential for convective heat transfer could be ignored. Despite this conclusion, the factor of 2 was retained in the models as a conservatism.

The SAR text in Section 3.5.2.1 has been revised to include this added explanation.

3-4 Compare the forced convection heat transfer coefficients applied during the hypothetical accident condition fire event computed using the relationships in Table 6-5 of Kreith (Kreith, Frank, Principles of Heat Transfer, 3rd edition, Harper & Row, 1973) for a flat surface with the values determined with the Sandia experiments described in "Thermal Measurements in a Series of Large Pool Fires," Sandia Report SAND85- 0196 TTC - 0659 UC 71, (August 1971).

SAR page 3-37 states that the forced convection heat transfer coefficients applied during the HAC fire event are computed using the relationships in Table 6-5 of Kreith (Kreith, Frank, Principles of Heat Transfer, 3rd edition, Harper & Row, 1973). However, the SAR does not explain why this correlation is valid or if it compares well with experimentally determined forced heat transfer coefficients during regulatory fires.

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

> ***Response:*** For the most part, the requested comparison can't be made since the Sandia report addresses the total heat flux on the surface of the test package arising from both convection and radiation, whereas the relationships in Table 6-5 of Kreith addresses only the convective portion. The referenced report does make two single point estimates of the convective heat transfer rate: 42 kW/m^2 at the stagnation point and 7 kW/m^2 at the sides of the cylinder. Based on paper's listed surface temperature of 423 K and flame temperature of approximately 1,283 K, the associated convective heat transfer coefficients are 49 W/m^2-K and 8 W/m^2-K, respectively.
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> The turbulent heat transfer coefficient relationship from Table 6-5 of Kreith is a modified version of the Colburn relation (i.e., $Nu = 0.036\ Pr^{1/3}\ Re^{0.8}$) recommended by the advisory material for IAEA (TS-G-1.1, Rev 1). The same advisory material states that "pool fire gas velocities are generally found to be in the range of 5–10 m/s." The SAR evaluation is based on an assumed fire gas velocity of 10 m/s which, with the assumed characteristic length of 0.25 feet and the Table 6-5 relationships, yields a forced convection heat transfer rate of approximately 40 W/m^2-K. This convection coefficient level is equal to that obtained using the IAEA recommended Colburn relation and is 5 times the sidewall convection coefficient (i.e., 8 W/m^2-K) estimated in the Sandia report.
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> The SAR text at the end of Section 3.5.2.3 has been modified to provide justification for using the Table 6-5 relationships.

Additional Changes Made to Revision 9:

1) In addition to the responses to the four thermal RAIs, the revision number for the fuel drawing number (footnote 5 in Section 3.2.1) has been removed. This change brings the thermal analysis into alignment with the criticality and structural analyses, which do not reference the fuel drawing revision number. This is justified since the information used to construct the fuel thermal model is not affected by any specific drawing revision.

2) In a letter dated July 23, 2013 from the Manager of the DOE Packaging Certification Program, James M. Shuler, to Michelle Sampson, NRC Licensing Branch Chief for the Division of Spent Fuel Storage and Transportation, the DOE requested some minor changes to the certificate of compliance for the ATR FFSC packaging. In brief, it was requested that the certificate language for Design Demonstration Elements (DDEs) be clarified to include similar test elements whose radiological and physical descriptions are bounded by those of the DDE, but which may not be denominated by the generic name "DDE".

Specifically, DOE requested the following changes to Revision 5 of the ATR FFSC CoC (changes in bold type):

Section 5.(b)(1), page 3, 3rd paragraph, change to read:

Small Quantity Payloads (RINSC fuel elements, ATR Full-size plate in Flux trap Position (AFIP) elements, U-Mo foils, Design Demonstration Elements (DDEs) **and similar test elements**, MIT loose fuel element plates, or MURR loose fuel element plates)...

Section 5.(b)(1), page 4, 3rd paragraph, change to read:

DDEs **and similar test elements**: The DDEs **and similar test elements** are composed of uranium molybdenum alloy in an aluminum-silicon matrix or uranium molybdenum alloy. The uranium is enriched to a maximum of 94 weight percent U-235. The maximum mass of U-235 is 365 grams. Loose plates from a DDE **or similar test element** are also permitted. The DDEs **or similar test elements** must be contained within the Small Quantity Payload Fuel Handling Enclosure, as specified in 5.(a)(3).

It was suggested by DOE in the referenced letter that these changes be made to the CoC without a SAR change. However, since the SAR is being revised at this time, this request has now been supported by two minor revisions in Chapter 1 (in Section 1.1 with identical language in Section 1.2.2).

3) A typographical error has been corrected in the title of Figure 1.2-17.

Updating instructions for the SAR are provided in the following table:

Remove Rev. 9 pages:	**Add Rev. 10 pages:**
Cover page & Spine	Cover page & Spine
Table of Contents, pages i through vi	Table of Contents, pages i through vi
Chapter 1, pages 1-1, 1-2, 1-8 thru 1-12, and 1-22.	Chapter 1, pages 1-1, 1-2, 1-8 thru 1-12, and 1-22.
Chapter 3, pages 3-6 thru 3-8, 3-22 thru 3-25, 3-32 thru 3-37, 3-77 and 3-78	Chapter 3, pages 3-6 thru 3-8, 3-22 thru 3-25, 3-32 thru 3-37, 3-77 and 3-78