71-9276

BNFL Fuel Solutions

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Subject: License Amendment Request for the FuelSolutions™ Transportation System Response to Request for Additional Information (TAC No. L23584)

Reference: Letter from USNRC to BNFL Fuel Solutions, "Request for Additional Information to the FuelSolutions™ Transportation System Amendment Request (TAC No. L23584)," dated June 13, 2003

Dear Sir or Madam:

This letter transmits the responses to the request for additional information (RAI) (provided via the reference letter) on the license amendment request (LAR) for the FuelSolutions™ Transportation System (LAR 03-01). This LAR, which requests certain specific changes to the Certificate of Compliance for the FuelSolutions™ Transportation System related to the decay heat limit for the FuelSolutions™ W21 Canister, has been revised to respond to requests made in the RAI. A summary of the changes and the bases for the changes are provided in the Summary of Changes included in the revised LAR.

Enclosed are 10 copies of the revised LAR 03-01, including Summary of Changes and Revision 5 change pages to the FuelSolutions™ Transportation Safety Analysis Reports. Should you or any member of your staff have any questions, please contact the undersigned at (408) 558-3509.

Sincerely,

Steven E. Sisley
Licensing/Regulatory Compliance Manager

Enclosures:
1. RAI Responses
2. LAR 03-01, Revision 5 change pages (controlled copies 2 - 11)
3. CD-ROM, Calculation CMPC.1605.201, Revision 1, ORIGEN2.1 input and output files.

NMSS01

WSNF-120, TS125 Transportation Cask SAR

CHAPTER 1 - GENERAL INFORMATION

1-1 Reword the second bullet on page 1.2-20: "The transportation cask can accommodate any Fuel Solutions canister... Alternatively, the SNF payload of any FuelSolutions canister can have a higher LHGR, provided that the canister thermal evaluation shows that the peak temperatures in the transportation cask's inner shell do not exceed those calculated for the bounding canister Qmax thermal profile in Chapter 3."

There appears to be an implied "71.48" approach which is not currently acceptable for transportation packages. Equivalent assertions can be found in Chapter 3 as well as in the W21 and W74 SARs. All these statements should be clarified or eliminated.

10 CFR 71.7(a) requires complete and accurate information.

BFS Response to 1.1:

The text referred to in the RAI is not intended to permit changes to be made without prior NRC approval (i.e., implied "71.48" approach). Rather, the intent is to define the canister thermal interface requirements for the TS125 transportation cask. In the event that changes to the package contents currently approved in the FuelSolutions™ Transportation System CofC are sought in the future, an application for license amendment would be submitted to NRC for review and approval in accordance with the requirements of 10CFR71, Subpart D.

In order to clarify the canister thermal interface requirements, the second bullet on page 1.2-20 has been reworded and the associated text throughout the FuelSolutions™ TS125 Transportation Cask SAR (WSNF-120), FuelSolutions™ W21 Canister Transportation SAR (WSNF-121), and FuelSolutions™ W74 Canister Transportation SAR (WSNF-123) has been revised. The text now states that the canister heat load must be 22.0 kW or less, and that the canister's thermal evaluation must show that the peak temperature in the cask's inner shell does not exceed the value calculated for the bounding Q_{max} thermal profile in Chapter 3 of WSNF-120.

Summary of SAR changes:

<u>WSNF-120</u>

- Revised Section 1.2.3.1, page 1.2-20, second bullet.

- Revised Table 1.2-3, page 1.2-27, "Maximum Amount of Decay Heat" and page 1.2-31, note 2.
- Revised Section 3.1.3.3, pages 3.1-8 and 3.1-9.

<u>WSNF-121</u>

- Revised Section 1.2.1.2, page 1.2-7, "Heat Dissipation." Corrected maximum LHGR from 106.6 watts/inch to 160.6 watts/inch.
- Revised Table 1.2-4, pages 1.2-20.
- Revised Section 3.1.3.3, page 3.1-8, first two paragraphs and bullet list.

<u>WSNF-123</u>

- Revised Section 1.2.1.2, page 1.2-6, "Heat Dissipation."
- Revised Table 1.2-4, pages 1.2-19 through 1.2-24.
- Revised Section 3.1.3.3, page 3.1-8, first two paragraphs and bullet list.

WSNF-121, W21 Canister Transportation SAR

<u>CHAPTER 3 – THERMAL EVALUATION</u>

3.1 Demonstrate that the data provided in Table 3.1-2 is indeed a normalized distribution. Table 3.1-2 does not provide the same level of detail (number of piecewise segments) as used for Figure 3.1-1. Address the effects of modifying Table 3.1-2 and/or Figure 3.1-1, if necessary, upon the overall thermal evaluations.

10 CFR 71.33 requires the applicant to provide a description in sufficient detail to identify the package accurately.

BFS Response to 3.1:

Although the thermal profile data provided in Table 3.1-2 is the same data used for the W21 canister thermal evaluation, Table 3.1-2 has been modified to more clearly show the heat generation at the ends of the profiles. In addition, the $LHGR_{max}$ profile data at the 70-inch and 100-inch axial locations have been corrected to match the data used in the W21 canister thermal models. Likewise, Figure 3.1-1 has been revised to show the same data used in the W21 canister thermal models and shown in the revised

Table 3.1-2. The modifications to Table 3.1-2 and Figure 3.1-1 have no effect on the W21 canister thermal evaluation because they match the data used in the thermal models.

The thermal profile data provided in Table 3.1-2 is indeed normalized. A normalized thermal profile has an average heat generation of 1.0 over its length. The integrated area under a normalized thermal profile is equal to the length of the profile. The areas under the thermal profiles shown in the revised Table 3.1-2 were determined by numerical integration (trapezoidal rule). The area under the Q_{max} profile is 150.2 inches, compared to the profile length of 150 inches. Similarly, the area under the $LHGR_{max}$ profile is 91.2 inches, compared to the profile length of 91 inches. The integrated areas under the thermal profiles are slightly larger than the profile lengths, which is conservative because slightly more heat is applied to the model than credited in the thermal evaluation.

Summary of SAR changes:

WSNF-121

- Revised Table 3.1-2 and Figure 3.1-1.

3.2 Modify Table 3.1-5 to include, for each of the burnup levels, the following information: fuel type (vendor & lattice matrix), enrichment, cycle length, number of cycles, cooling time, and mass of Uranium. Justify why the information provided above is bounding. Provide all supporting ORIGEN2.1 calculations for Table 3.1-5. Identify the amount of decay heat associated with the control rod inserts.

10 CFR 71.7(a) requires complete and accurate information.

BFS Response to 3.2:

Table 3.1-5 has been modified to include the requested information. For each burnup, Table 3.1-5 now shows the initial ^{235}U enrichment and cooling time upon which the heat generation calculations are based. In addition, a note has been added to Table 3.1-5 that includes the uranium loading used in the calculations and that references Table 5.2-1 for other parameters (including fuel type and cycle history) used in the calculations. Similar modifications have been made to Table 3.1-6.

The parameters used for the calculations of the Table 3.1-5 heat generation data are conservative and bounding as follows:

- The calculations are based on the combinations of allowable burnup, initial enrichment, and cooling time from Table 5.1-3 that produce the highest assembly heat generation levels.

- The calculations are performed using the maximum uranium loading permitted by the fuel specification.

- The calculations are performed using the most conservative power history possible, i.e., a single, continuous irradiation period with no down periods.

The ORIGEN2.1 calculations for Table 3.1-5 are described in calculation CMPC.1605.201, which was previously provided to NRC. A CD-ROM containing all of the ORIGEN2.1 output files from calculation CMPC.1605.201 is provided with this RAI response.

Table 3.1-5 includes heat generated from activated assembly metal hardware, expressed as an upper-bound percentage of the total assembly heat for each burnup level. As explained in Section 3.1.3.4, the percentages of heat from assembly hardware are obtained from a published report. Although the referenced report does not specifically state that inserted control components are included in the calculated assembly hardware heat, alternative analyses performed by BFS demonstrate that the assembly hardware heat contributions shown in Table 3.1-5 cover (i.e., conservatively bound) the presence of any control component.

The alternative analysis of heat generated by assembly hardware, including inserted control components, was performed using ORIGEN2.1 for the combinations of allowable burnup, initial enrichment, and cooling time evaluated in Table 3.1-5, and for the corresponding maximum assembly/insert fuel zone cobalt content of 11 grams per assembly. (Note that, to load fuel having the shorter cooling times upon which Table 3.1-5 is based, the total quantity of cobalt present in the fuel assembly and inserted control components must not exceed 11 grams.) As discussed in the following paragraph, heat generated by the portions of assembly hardware and a control component located outside the fuel zone is negligible and was not considered in this analysis. The resulting heat generation from assembly hardware in the fuel zone is presented in Table 3.1-6 for each burnup level. When expressed in terms of the percentage of the total assembly heat from Table 3.1-6, the results show that the heat contribution from assembly hardware and inserted control components is significantly lower than the bounding percentages presented in Table 3.1-5.

Many inserted control components contain hardware that is located outside the fuel zone (i.e., within the assembly gas plenum and top nozzle zones). As shown in calculation CMPC.1605.201, virtually all of the assembly hardware heat generation is due to the decay of ^{60}Co. In the W21 canister shielding evaluation, the ^{60}Co activity present in each non-fuel assembly zone (bottom nozzle, gas plenum, and top nozzle) was determined for each of the burnup, initial enrichment, and cooling time combinations in Table 5.1-3. These ^{60}Co activity levels, which are conservatively based on the fuel assembly and insert type having the highest overall ^{60}Co content, are reported in Tables 5.2-7 through 5.2-9. The highest combined ^{60}Co activity level for all PWR assembly zones outside the fuel zone is approximately 572 Ci (35 GWd/MTU, 6-year-cooled). Multiplying this ^{60}Co activity by the conversion factor of 0.015 watts/Ci yields a total assembly hardware heat generation level of only 8.6 watts, which is only 1% of the total heat load for 35 GWd/MTU fuel shown in Table 3.1-5. For a burnup of 60 GWd/MTU, which corresponds to the highest assembly heat load, the combined ^{60}Co activity level for all assembly zones located outside the fuel zone is approximately 150 Ci. This yields a total assembly hardware heat generation level of only 2.3 watts, or 0.2% of the total heat load from Table 3.1-5. Therefore, this heat generated by assembly and control insert hardware located outside the fuel zone is negligible.

Summary of SAR changes:

WSNF-121

- Revised Table 3.1-5 and Table 3.1-6.

3.3 Provide the basis for the values in Table 3.1-6 under columns "UO_2 Fuel" and "Fuel Zone Hardware." Provide the reason for using average burnup (assumed in Table 3.1-5) when deriving peaking factors and the associated margins in Table 3.1-6.

The heat associated with the fuel zone hardware doesn't seem to be smeared over the same length (144 inches) as the UO_2 fuel heat. The assembly hardware heat identified in Table 3.1-5 does not seem to be considered in Table 3.1-6. Clarify whether the assembly hardware heat is within the active fuel length. Discuss the heat from the control rod inserts.

In order to come up with applicable peaking factors to derive safety margins, appropriate burnup axial profiles should have been used, instead of relying on the results from Table 3.1-5 which assume a uniform burnup along the length of the fuel. Based on Figure 3.1-3, among the ORNL study population there was one PWR fuel with a peaking factor of approximately 1.15 at 55 GWD/MTU. This fact reduces the assembly peaking factor margin presented in Table 3.1-6 from 1.207 to 1.050, which is close to the thermal design limit. The ORNL study does not go beyond the 55 GWD/MTU burnup level and no consideration is given to uncertainties in burnup as well as to the accuracies of the involved codes.

10 CFR 71.7(a) requires complete and accurate information.

BFS Response to 3.3:

The spent fuel thermal peaking profiles shown in Figures 3.1-2 and Figure 3.1-3 are not directly related to reported W21 thermal margins, nor to their calculation. The terms "peaking factor margin" and "allowable" used in these figures were misleading and have been revised because peaking factors are not used to qualify fuel and are not directly related to thermal margin. The figures, table, and the accompanying discussion in Section 3.1.3.4 of WSNF-121, have been revised for brevity to:

- Clarify that fuel meeting the minimum cooling time required by Chapter 5 of WSNF-121 is also acceptable from a thermal standpoint
- Remove any suggestion that peaking factors are the basis for specifying fuel acceptance or evaluating thermal margin
- More clearly discuss the W21 thermal margin

What follows is a complete response to RAI 3-3, divided into items A-H below for clarity. Since some of the issues concern the W21 thermal margin, it is appropriate to first provide a brief summary of the margin, and how the axial profiles affect thermal margin.

The FuelSolutions™ TS125 transportation cask is qualified for a maximum heat load of 22.0 kW.[1] The safety calculations were performed using two design basis axial heat generation profiles. One profile, called Q_{max}, was designed to challenge the cask with a high, flat heat load similar to a high-burnup fuel assembly. The second profile, called $LHGR_{max}$, challenges the cask with a maximum thermal gradient similar to a hotter, shorter fuel assembly. For each case, a normalized axial profile was constructed. The resulting computer models were run iteratively, increasing the total heat generation for each profile until a cask body temperature limit was approached.

WNSF-120, Section 3.1.3.3, states that FuelSolutions™ canister SARs must determine the appropriate thermal limit for each FuelSolutions™ canister design, which must not exceed 22.0 kW. Since the W21 canister was used as the design basis case for the TS125 transportation cask design, the maximum W21 canister heat load is also 22.0 kW. However, since the canister thermal limit is determined independently of other important fuel qualification constraints, such as dose rates and cooling times, qualified fuel might not have heat loads equal to the canister's thermal limit.

Fuel assemblies are qualified for transportation if they meet the cooling time requirements in Chapter 5 of WSNF-121. These cooling times were developed to assure that both the thermal and shielding requirements are satisfied. The required cooling times for fuel assemblies to be transported in the W21 canister turn out to be

[1] WSNF-120, TS125 Transportation SAR, Section 3.1.3.3.

governed by radiological, not thermal, constraints. In fact, Table 3.1-5 of WSNF-121 shows that acceptable fuel assemblies will never have a heat load equal to the Q_{max} design basis assembly (22.0/21 = 1.05 kW/assembly) and most will be substantially lower. As an example, a qualifying 40 GWd/MTU assembly will only be 77% of the heat load used in the Q_{max} thermal analysis case. This effect is a considerable source of thermal margin above and beyond the margin already identified in WSNF-121.

By comparing the system temperature margins for the two design basis thermal profiles, we can see that lowering the overall heat load increases the limiting thermal margin more than it is offset by increased LHGR. This is shown by noting that while the more highly peaked profile, $LHGR_{max}$, raised peak system temperatures inside the canister, it lowered them in the cask walls. Since the governing thermal margin is in the neutron shield, this effect translates to a higher minimum thermal margin for the $LHGR_{max}$ case.

Table A below summarizes the thermal margins for the Q_{max} and $LHGR_{max}$ cases evaluated in WSNF-121.[2] The $LHGR_{max}$ case featured a shorter fuel type (91-inch vs. 150-inch active length, or 39% shorter) with a lower total heat load (17.5 kW vs. 22.0 kW, or 20% lower), and a significantly higher LHGR (0.211 kW/inch-canister vs. 0.1606 kW/inch-canister, or 31% higher). By comparison, this fuel would produce 29 kW if it had the 150-inch active length used for the Q_{max} model. The table shows that the thermal capacity of the W21 canister system is limited by the neutron shield material, where the thermal margin is 10°F. The sensitivity of this worst-case margin to more highly peaked thermal profiles can be seen in the $LHGR_{max}$ case. For this case, the neutron shield margin was seen to increase from 10°F to 33°F. The tradeoff was a decrease in fuel cladding margin from 102°F to 48°F (but still showing a significant margin). The comparison demonstrates that the limiting thermal margin is more sensitive to the 20% decrease in Q than the 31% increase in LHGR.

[2] Data taken from WSNF-121, FuelSolutions™ W21 Canister Transportation SAR, Tables 3.4-1 and 3.4-2.

Table A - Summary of Thermal Margins

Component	Case Q_{max} [1]	Case $LHGR_{max}$ [2]	Temp Limit (°F)	Change in margin Q_{max} to $LHGR_{max}$ Case (°F)
	Peak Temp (°F)			
Peak Fuel Cladding	649.6	703.6	752	102.4 to 48.4, (lower margin)
Guide Tube	611	654	800	189 to 146, (lower margin)
Spacer Plates				
Stainless Steel	601	646	800	199 to 154, (lower margin)
Carbon Steel	602	644	700	98 to 56, (lower margin)
Support Rod	533	566	700	167 to 134, (lower margin)
Canister Shell	464	484	800	336 to 316, (lower margin)
Inner Cask Shell	358	356	800	442 to 444, (higher margin)
Gamma Shield (Lead)				
Maximum	352	348	620	268 to 272, (higher margin)
Bulk Average	319	282	620	301 to 338, (higher margin)
Outer Cask Shell	330	324	800	470 to 476, (higher margin)
NS-4-FR Shield				
Max. Radial Avg.	290	267	300	10 to 33, (higher margin)
Bulk Average	~~252~~	~~227~~	~~300~~	~~48 to 73, (higher margin)~~
Neutron Shield Jacket				
Near Shear Block	261	241	350	89 to 109, (higher margin)
Elsewhere	215	225	350	135 to 125, (lower margin)
Personnel Barrier	139	137	185	46 to 48, (higher margin)
Impact Limiter				
Max. Honeycomb	162	167	300	138 to 133, (lower margin)
Bulk Avg. Honeycomb	148	151	200	52 to 49, (lower margin)
Cask Metallic Seals				
Cask Closure	237	249	932	695 to 683, (lower margin)
Vent & Drain Ports	232	232	662	430 to 430, (no change)

Source: WSNF 121, FuelSolutions™ W21 Canister Transportation SAR, Tables 3.4 1 and –2.

Notes: 1. Q=22.0 kW, L = 150 in, peak LHGR = 0.1606 kW/canister-in

2. Q=17.5 kW, L = 91 in, peak LHGR = 0.211 kW/canister-in

A. **Provide the basis for the values in Table 3.1-6 under columns "UO_2 Fuel" and "Fuel Zone Hardware."**

BFS Response to 3-3 (Part A):

The "UO_2 Fuel" column was derived using the following steps for each burnup level.

1. Find the initial enrichment and cooling time combination shown in Table 5.1-3 of WSNF-121 that yields the maximum heat generation rate. The lower cooling

time cases in Table 5.1-3 always yield the highest (most conservative) heat loads, as discussed in BFS Calculation CMPC.1605.201.

2. Run ORIGEN2.1 to calculate the heat generation from one kg of fuel material for the desired enrichment and cooling time.

3. Multiply the heat generation rate by 3.27 kg/inch-assembly, which is bounding for all PWR assemblies.

The "Fuel Zone Hardware" column was derived using the following steps for each burnup level.

1. Determine the heat generation rate for 11 grams of ^{60}Co in the active fuel zone (11 g ^{60}Co is specified in Chapter 5) using ORIGEN2.1. The CMPC.1605.201 analyses found that virtually all assembly hardware heat generation is from ^{60}Co decay, which in turn is directly proportional to the amount of cobalt initially present.

2. Divide the rate by a lower-bound active length of 128 inches to determine the heat generation contribution from one inch of the active fuel zone. The shorter length is conservative since it results in a higher contribution to the LGHR. All PWR assemblies have an active fuel length of 128 inches or more, except the Yankee Rowe fuel. The Yankee Rowe assembly was excluded as a choice for the bounding case, however, since its fuel zone cobalt quantity is known to be much less than 11 g.

Summary of SAR changes:

WSNF-121

- Revised Table 3.1-6 and related discussion in Section 3.1.3.4.

B. Provide the reason for using average burnup (assumed in Table 3.1-5) when deriving peaking factors and the associated margins in Table 3.1-6.

BFS Response to 3-3 (Part B):

Peaking factors are a peak-to-average ratio. In Table 3.1-6, the "peak" is the LHGR for the Q_{max} case, and the "average" is the active fuel zone's average LHGR for the average burnup, enrichment, and cooling time combination of interest. The average LHGR is the total heat generated in the active fuel zone divided by the active fuel zone length. To obtain the total heat in the active fuel zone, it is appropriate to use the average burnup, rather than a peak burnup value.

It should be noted that Table 3.1-5 was compiled on the basis of total fuel assembly heat load, while Table 3.1-6 was compiled on the basis of active fuel zone only. Although the same burnup-enrichment state points were used for both tables, none of the data in Table 3.1-5 was used for the construction of Table 3.1-6.

Summary of SAR changes:

WSNF-121

- Revised Tables 3.1-5 and 3.1-6, Figure 3.1-2, and the related discussion in Section 3.1.3.4.
- Deleted Figure 3.1-3 (a "blowup" view of Figure 3.1-2).

C. The heat associated with the fuel zone hardware doesn't seem to be smeared over the same length (144 inches) as the UO_2 fuel heat.

BFS Response to 3-3 (Part C):

The heat associated with the fuel zone hardware is not smeared over the same length (144 inches) as the UO_2 fuel heat. The UO_2 heat generation rate is based on the worst-case PWR axial heavy metal loading of 3.27 kg/inch-assembly, not a specific fuel design. The fuel zone hardware heat in Table 3.1-6 was obtained by dividing the thermal source for the fuel zone hardware by 128 inches, which is the shortest active fuel length for any U.S. PWR fuel assembly.[3] Using the shortest PWR active fuel length is conservative because it concentrates the heat load over a smaller length. The calculations shown in Table 3.1-6 were not used in the thermal safety analyses. These calculations were only prepared to support the discussion of LHGR ratio in Section 3.1.3.4 and Figure 3.1-2.

Summary of SAR changes:

WSNF-121

- Revised Table 3.1-6.

[3] One U.S. PWR assembly type, the Yankee Rowe assembly, has an active fuel length shorter than 128 inches. Despite the Yankee Rowe assembly's 91-inch active fuel zone, it is not the bounding case with respect to average LHGR from fuel-zone assembly hardware, because its fuel zone cobalt quantity is known to be much lower than the design-basis value of 11 grams/assembly.

D. The assembly hardware heat identified in Table 3.1-5 does not seem to be considered in Table 3.1-6.

BFS Response to 3-3 (Part D):

The assembly hardware heat identified in Table 3.1-5 is not considered in Table 3.1-6. Table 3.1-5 considers the total heat produced by the fuel assembly, counting all heat from UO_2 and from activated fuel assembly hardware and control components inside and outside the active fuel region. Table 3.1-6 considers heat produced from the same sources *inside the active fuel region only*. The LHGR outside the active fuel region of the assembly is lower than the LHGR inside the active fuel region, and is not required for the calculation of the LHGR ratio. This is acceptable because the purpose of Table 3.1-6 is to calculate the LHGR ratios for each burnup level that would be required to match the peak LHGR of the design basis thermal profile. For this purpose, it is not necessary to consider sources outside the active fuel region.

Summary of SAR changes:

<u>WSNF-121</u>

- Revised Tables 3.1-5 and 3.1-6.

E. Clarify whether the assembly hardware heat is within the active fuel length. Discuss the heat from the control rod inserts.

BFS Response to 3-3 (Part E):

The LHGR calculations in Table 3.1-6 only include the heat input from UO_2, assembly hardware, and control rod inserts *within the active fuel zone* because the heat generation outside the active fuel zone does not contribute to the calculation of the LHGR ratio. The UO_2 contribution was calculated by modeling 3.27 kg in ORIGEN2.1. This model is conservative because 3.27 kg is the bounding amount of UO_2 in an inch of PWR fuel assembly. The contribution from assembly hardware and control components was calculated by modeling 11 g of cobalt in ORIGEN2.1 and dividing the resulting heat by 128 inches to determine the LHGR contribution. This model is conservative because the cooling times in Chapter 5 are specified for a maximum of 11 grams of cobalt in the active fuel zone.

Note that Table 5.1-3 actually presents two combinations of enrichment and cooling time for each burnup level. There is a short cooling time, which is based upon the higher initial enrichment (along with an a lower assembly fuel zone hardware cobalt quantity of 11 grams), and there is a long cooling time, which is based upon the lower initial enrichment (along with an a higher assembly fuel zone hardware cobalt quantity of 50 grams). The ORIGEN2.1 analyses show that for any given burnup level, the low-cooling-time, high-enrichment case (shown in Table 5.1-3) always yields a higher heat generation level than the high-cooling-time, low-enrichment case. Therefore, only the low-cooling-time cases and corresponding 11 g of cobalt are applicable.

The calculations in Table 3.1-6 were not used for the thermal safety analyses.

Summary of SAR changes:

WSNF-121

- Revise the discussion in Section 3.1.3.1.

F. In order to come up with applicable peaking factors to derive safety margins, appropriate burnup axial profiles should have been used, instead of relying on the results from Table 3.1-5 which assume a uniform burnup along the length of the fuel.

BFS Response to 3-3 (Part F):

See response to 3-3 (Part B) of this RAI.

G. Based on Figure 3.1-3, among the ORNL study population there was one PWR fuel with a peaking factor of approximately 1.15 at 55 GWD/MTU. This fact reduces the assembly peaking factor margin presented in Table 3.1-6 from 1.207 to 1.050, which is close to the thermal design limit.

BFS Response to 3-3 (Part G):

The figures and text have been revised to clarify that the curve in Figure 3.1-2 is not a limit; instead, the curve corresponds to additional thermal margin above and beyond the margin identified in the thermal calculations. The curve maps the Q_{max} case profile used for the thermal evaluations into BU-PF space for the purpose of comparison to the U.S. PWR fuel inventory. Although the curve happens to envelope every single point in the burnup database, many fuel assemblies with significantly higher peaking factors would be thermally acceptable as demonstrated by the $LHGR_{max}$ case discussed above. The fact that the curve envelopes all the database points illustrates the conservatism used in constructing the design basis Q_{max} case thermal profile.

Since the neutron shield material temperatures drive the thermal limits for the W21 system, it is the overall heat load of the fuel (vs. the LHGR) that governs the thermal margin. This is because the thick cask walls tend to "wash out" axial differences in heat generation rates. The reduced overall heat loads of assemblies that meet the cooling times in Table 5.1-3 therefore offset the local effects of higher LHGR values.

As discussed in the general response to this RAI, terms previously used that implied that the peaking factors and LHGR values were limited by the design basis axial heat generation profiles have been revised. All references to "bounding" thermal profiles have been changed to "design basis" thermal profiles. In addition, the terms "peaking factor margin" and "allowable" have been revised as discussed in the general response to this RAI.

Summary of SAR changes:

WSNF-120

- Revised Sections 3.1.3 and 3.1.3.1 to replace the term "bounding" with "design basis" when used in reference to thermal profiles.

WSNF-121

- Revised Sections 2.6.1.1, 3., 3.1.3 and 3.1.3.1 to replace the term "bounding" with "design basis" when used in reference to thermal profiles.
- Revised Table 3.1-6, Figure 3.1-2, and the related discussion in Section 3.1.3.4.
- Deleted Figure 3.1-3 (a "blowup" view of Figure 3.1-2).

WSNF-123

- Revised Sections 3.1.3, 3.1.3.1, 3.4.2, 3.6.4.2, 3.6.5.2, and Table 3.1-3 to replace the term "bounding" with "design basis" when used in reference to thermal profiles.

H. The ORNL study does not go beyond 55 GWD/MTU burnup level and no consideration is given to uncertainties in burnup as well as to the accuracies of the involved codes.

BFS Response to 3-3 (Part H):

The data in Table 3.1-6 and Figure 3.1-2 serve only to illustrate the additional margin that exists above and beyond the temperature margins indicated in the thermal analysis. The data are not used in the safety calculations. It is noteworthy that the LHGR ratios exceed the peaking factor for every one of the 3,169 fuel histories in the database, but it is not imperative that every peaking factor be less than the LHGR ratio curve.

Unlike criticality, where system performance is very sensitive to the fuel characteristics (e.g., enrichment or geometry) of even a small number of fuel assemblies, the safety calculations show, as discussed above, that the response of the W21 thermal margins with respect to burnup, axial profiles, etc., is not sensitive enough to warrant detailed consideration of uncertainties in burnup or code accuracy.

Summary of SAR changes:

None.

3.4 Address the accuracy of ORIGEN2.1 when predicting heat loads from low to high burnup conditions. Provide supporting references.

10 CFR 71.7(a) requires complete and accurate information.

BFS Response to 3.4:

The accuracy of the heat loads predicted using ORIGEN2.1, over a range of assembly burnup levels, is addressed in calculation CMPC.1503.011, which was transmitted to the NRC in the volume of supporting calculations for WSNF-200. In this calculation, a source term comparison between ORIGEN2.1 and SAS2H was made for a wide range of assembly burnup levels and initial enrichment levels. This comparison shows good agreement (within a few percent) between the PWR assembly heat generation levels calculated using the ORIGEN2.1 and SAS2H codes. The results also show that ORIGEN2.1 tends to predict higher heat loads than SAS2H for lower enrichments and/or higher burnup levels (i.e., for assembly parameters than yield maximum heat loads).

The accuracy of ORIGEN2.1 for predicting heat loads is also addressed in a report prepared by Oak Ridge National Laboratory,[4] in which ORIGEN2 calculation results were compared with measured spent fuel data and with the ANS 5.1 standard, which is

[4] A. Croff, Oak Ridge National Laboratory, "ORIGEN2: A Versatile Computer Code for Calculating the Nuclide Compositions and Characteristics of Nuclear Materials," Nuclear Technology, Volume 62, September 1983.

widely used for determining spent fuel decay heat. The report compared assembly heat loads calculated using ORIGEN2 to measured heat load data for 30 GWd/MTU PWR spent fuel assemblies from the Turkey Point Unit 3 reactor and the H. B. Robinson Unit 2 reactor. The comparison showed that ORIGEN2 calculations over-predicted spent fuel assembly heat generation levels by 5 to 6%. The comparison of ORIGEN2 calculations to the ANS 5.1 standard also shows good agreement (within ± 2%) for decay times ranging from less than 1 minute to 30 years.

Summary of SAR changes:

None.

WSNF-123, W74 Canister Transportation SAR

CHAPTER 3 – THERMAL EVALUATION

3.1 Revise the data in Table 3.1-2 so that the active lengths of both Big Rock Point axially stacked fuels are 70 inches. Justify that Table 3.1-2 is equivalent to Figure 3.1-1. Demonstrate that the data provided in Table 3.1-2 is a normalized distribution. Address the effects of modifying Table 3.1-2 and/or Figure 3.1-1, if necessary, upon the overall thermal evaluations.

Table 3.1-2 shows the active length of the lower fuel assembly spanning from 13" to 83" above the bottom of the canister, which indicates an active length of 70 inches. The top fuel assembly, however, spans from 98" to 170" above the bottom of the canister, which implies an active length of 72 inches. Figure 3.1-1 shows the top fuel assembly positioned between 100" and 170" above the bottom of the canister, which is in conflict with the data in Table 3.1-2. Note that Table 6.2-1 indicates all BRP fuel as having active length of 70 inches.

BFS Response to 3.1:

The Table 3.1-2 thermal profile data has been modified to more clearly show the heat generation at the ends of the profiles and to include additional data points at the 17.4-inch and 164-inch axial locations from the W74 canister thermal model profile. In addition, Figure 3.1-1 has been modified to match the revised thermal profile data in Table 3.1-2.

The Table 3.1-2 thermal profile data for the fuel in the upper basket has not been modified to model a 70-inch active fuel length. The thermal profile for the fuel in the upper basket was conservatively modeled with a 72-inch length, resulting in slightly more heat generation than is credited in the thermal evaluation. The differences between the thermal profiles of the fuel in the upper and lower baskets have no significant effect on the results of the thermal evaluation.

The thermal profile data used in the W74 thermal evaluation and shown in the revised Table 3.1-2 is normalized. A normalized thermal profile has an average heat generation of 1.0 over its length. Thus, the integrated area under a normalized thermal profile is equal to the length of the profile. The area under the thermal profile shown in the revised Table 3.1-2, which was determined by numerical integration (trapezoidal rule), is 140.4 inches. The integrated area under the thermal profile is slightly larger than the 140-inch total active fuel length, which is conservative since slightly more heat (0.3%) is applied to the model than is credited in the thermal evaluation.

Summary of SAR changes:

<u>WSNF-123</u>

- Revised Section 3.1.3.1, pg. 3.1-7, 2nd paragraph.
- Revised Table 3.1-2 and Figure 3.1-1.

3.2 Editorial: The last sentence in Section 3.1.3.3: "Thus, the W74 canister containing BRP SNF assemblies meeting the can be shipped in the TS125 transportation cask." is incomplete.

BFS Response to 3.2:

The last sentence in Section 3.1.3.3 has been deleted since it is not required.

Summary of SAR changes:

<u>WSNF-123</u>

- Deleted the last sentence in Section 3.1.3.3.

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Revision 5 Change Page Insertion Instructions

Remove	Insert
LAR binder inserts	LAR binder inserts
LAR cover sheet	LAR cover sheet
Summary of SAR Changes (pgs. 1 through 10)	Summary of SAR Changes (pgs. 1 through 8)
WSNF-120	
i–xxvi	i–xxvi
1.2-19 through 1.2-22	1.2-19 through 1.2-22
1.2-27 and 1.2-28	1.2-27 and 1.2-28
1.2-31 and 1.2-32	1.2-31 and 1.2-32
3.1-5 through 3.1-16	3.1-5 through 3.1-14
WSNF-121	
i–xx	i–xx
1.2-7 and 1.2-8	1.2-7 and 1.2-8
1.2-19 and 1.2-20	1.2-19 and 1.2-20
2.6-1 and 2.6-2	2.6-1 and 2.6-2
3-1 and 3-2	3-1 and 3-2
3.1-5 through 3.1-22	3.1-5 through 3.1-18
---	3.4-7 and 3.4-8
WSNF-123	
i–xxiv	i–xxiv
1.2-5 and 1.2-6	1.2-5 through 1.2-8, and 1.2-19 through 1.2-24
3.1-5 through 3.1-8, and 3.1-11 through 3.1-16	3.1-5 through 3.1-16
3.4-7 and 3.4-8	3.4-7 and 3.4-8
3.4-13 and 3.4-14	3.4-13 and 3.4-14
3.6-9 through 3.6-12	3.6-9 through 3.6-12