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March 7, 2008

Mr. Stewart Brown, Project Manager
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852-2738

Subject: Minutes of the February 15, 2008 MAGNASTOR Draft RAI Teleconference
Docket No. 72-1031 (TAC No. L23764)

Dear Mr. Brown:

NAC International (NAC) hereby submits the subject minutes documenting the discussions and clarifications for each Draft RAI provided to NAC by FAX February 14, 2008 and discussed with the NRC staff February 15, 2008. As discussed during the teleconference, clarification beyond the actual discussion during the teleconference and proposed edits to SAR text are included in the attached document as appropriate with each respective Draft RAI.

This submittal includes eight copies of this transmittal letter and eight copies of the Attachment 1 – MAGNASTOR Draft RAIs, NRC Conference Call February 15, 2008. Upon NRC review and approval, the proposed SAR changes will be incorporated into a formal SAR supplement to the MAGNASTOR SAR currently under review.

If you have any questions regarding this submittal, please contact me at 678-328-1274.

Sincerely,

Thomas A. ... for

Anthony L. Patko
Director, Licensing
Engineering

Attachment 1 – MAGNASTOR Draft RAIs, NRC Conference Call February 15, 2008

NMSS01

ED20080025

Draft RAI Teleconference
Docket No. 72-1031, (TAC No. L23764)
March 7, 2008

MAGNASTOR Draft RAIs
NRC Conference Call February 15, 2008

Participants

NRC: Stewart Brown, Ed Hackett, Larry Campbell, Mike Waters, Mike Call, Zhian Li, Jorge Solis, David Tang

NAC: Tom Danner, Mike Yaksh, Holger Pfeifer

General Discussion

Stewart Brown, acting PM, initiated the conference call to review Draft RAIs prepared by the technical staff and to introduce the NRC proposed path for resolution of the Draft RAIs.

Ed Hackett summarized the proposed guidance being adopted as that used by NRR and defined in LIC-101, *Licensing Amendment Review Procedures*, in order to expedite documentation and closure of RAI issues. The guidance being implemented is to have "the licensee include the questions from the teleconference, e-mail, or fax in their docketed response." It is the intent of the call to review each question and determine if it can be closed with teleconference discussion, editorial/or clarification revision to SAR text, or if additional material is required to be addressed. Each draft RAI will be categorized as a respective category 1, 2 or 3. Category 1 represents that the teleconference discussion has resolved the question; no additional information is required. Category 2 indicates minor SAR text edit is required to close the issue. Category 3 represents a staff issue that requires additional information from NAC to resolve the NRC question that may, or may not require a change to the SAR text.

Following this brief introduction, each draft RAI provided by fax was discussed. The following summary is provided in the order of the organized RAI for clarity and consistency and is not representative of the actual sequence of the discussion.

The format adopted for each question is 1) Statement of the RAI, 2) Summary of Technical Discussion, 3) Proposed Resolution, Category and 4) Draft SAR Text Change.

The following table summarizes the Draft RAI disposition relative to the NAC proposed Category evaluation.

Chapter	**# of Draft RAI's**	**Category**		
		1	**2**	**3**
3	7	2	5	
4	7	1	5	1
6	5		3	2
8	1		1	
9	4	1	3	
12	1	1		
13	4		4	
CoC	1		1	
Total	**30**	**5**	**22**	**3**

Chapter 3.0 Structural Evaluation

Section 3.4.3.2 TSC Lift

3-1 Draft RAI

Clarify on page 3.4-14 why the safety factors of 6 and 10, against the respective yield and ultimate strengths, are not considered in evaluating the non-redundant TSC lift when only one three-legged sling is used in the finite element model as described in Section 3.10.3. Also, provide appropriate annotations in Figure 3.10.3-1 to depict the three-hoist ring boundary condition considered for the finite element half-symmetry TSC lift model.

Section 3.4.3.2 of the SAR notes that the hoist rings are analyzed as a redundant system per the stress factor criteria in NUREG-0612 and ANSI N14.6. The factors of safety of 3 and 6 called for non-redundant systems in Page 3.4-14 appear to be out of context. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. Accurate and complete information should be provided to meet the 10 CFR 72.11(a) requirements.

Summary of Technical Discussion

NAC provided a discussion of the finite element evaluation on page 3.4-14 that applied loading to 3 of the 6 sling attachment points, which is consistent with the definition of redundant loading. The stresses are to be compared to safety factors 3 and 5. To be consistent with the use of safety factors 3 and 5, the last sentence on the referenced page will be revised to agree with the discussion by changing "nonredundant" to "redundant."

Proposed Resolution
Category 2

NAC agrees to provide an edit to SAR Section 3.4.3.2 providing the requested clarification.

Draft SAR Text Change

Proposed text: reference page 3.4-14
"The criteria of NUREG-0612 and ANSI N14.6 for redundant systems are met."

Section 3.7.2 Fuel Basket Evaluation for Storage Accident Events

3-2 Draft RAI

Correct the following underscored typographical or editorial errors:

(1) Page 3.7-62. "[A]s described in Section 3.1.1, a quarter-symmetry finite element …"
(2) Pages, 3.10.1-5 and 3.10.2-5. "[T]he location of the outer nodes…during the VCC tip-over accident…"

The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. Accurate and complete information should be provided to meet the 10 CFR 72.11(a) requirements.

Summary of Technical Discussion

NAC acknowledged the typographical and editorial errors in the text.

Proposed Resolution
Category 2

NAC agrees to provide an edit to the referenced SAR sections.

Draft SAR Text Change

Proposed text: Reference page 3.7-62
"As described in Section ***3.10.4.3***, a quarter-symmetry finite element model of the pedestal is used for this evaluation."

Proposed text: Reference page 3.10.1-5
"The location of the outer nodes of the gap elements at the basket periphery incorporates the canister shell displacements during the ***concrete cask*** tip-over accident"

Proposed Text: Reference page 3.10.2-5
"The location of the outer nodes of the gap elements at the basket periphery incorporates the canister shell displacements during the ***concrete cask*** tip-over accident."

Section 3.8 Fuel Rods

3-3 Draft RAI

Revise Section 3.8 of the SAR fuel rod structural analysis for the 24-inch handling height concrete cask vertical drop accident. Add a fuel rod structural integrity evaluation for the side-drop impact associated with the concrete cask tip-over accident.

The applicant has previously submitted a proprietary report on fuel clad structural integrity for both the 24-inch handling height drop and non-mechanistic tip-over accidents. Relevant details should be summarized and presented in the SAR for the staff to make safety findings. Demonstration of fuel rod structural integrity is needed in the SAR to document that the spent fuel is in a sub-critical condition under credible conditions. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. This information is needed to demonstrate compliance with 10 CFR 72.236(c).

Summary of Technical Discussion

Discussion of this draft RAI acknowledged that there were no technical issues to be addressed regarding the proprietary analyses of the fuel clad being subjected to the 24-inch drop or the side-drop impact analyses configuration included as the bounding configuration for the tip-over accident loading. These analyses are to be included in the SAR as a revision to material currently presented in Section 3.8.1 and the addition of Section 3.8.4.

Proposed Resolution
Category 2

NAC agrees to provide a description of the analyses of the 24-inch end drop and tip-over/side drop configuration in Section 3.8 of the SAR to summarize the analytical model and analysis results previously provided to the NRC as NAC Calculation 71160-2026, Rev 0.

Draft SAR Text Change

Section 3.8.1 will be replaced by the following presentation:

3.8.1 PWR Fuel Rod Buckling Evaluation

This section presents the buckling evaluation for MAGNASTOR high burnup PWR fuel (burnup greater than 45,000 MWd/MTU) having cladding oxide layers that are 80 and 120 microns thick. A reduced cladding thickness is assumed due to the cladding oxide layer. These analyses show that the maximum stresses in the high burnup PWR fuel remain below the yield strength in the design basis accident events and confirm that the fuel rods will return to their original configuration. A 24-inch end drop orientation of the concrete cask subjects the fuel rods to axial loading. The 24-inch drop evaluation employs two acceleration time histories. The 24-inch concrete cask end drop described in Section 3.10.4.3 resulted in the acceleration time history shown in Figure 3.7.3-2. The maximum acceleration for the time history shown in Figure 3.7.3-2 is 25.3g's (the strong segment of the pulse lasts for 0.015 second). A bounding triangular shaped time history with a maximum acceleration of 45g's for a duration of 0.02 second is also used.

In the end drop orientation, the fuel rods are laterally restrained by the grids and come into contact with the fuel assembly base. The only vertical constraint for the fuel rod is the base of the assembly. As opposed to employing a straight fuel assembly in the evaluation with all the grids present, the fuel assembly is considered to be bowed, and a fuel assembly grid may be missing and still meet the acceptable configuration for undamaged fuel. The evaluation of the PWR fuel rods is based on the following representative samples.

Fuel Assembly	Cladding Diameter (in)	Cladding Thickness (in)	Fuel Rod Pitch (in)	Gap Between Fuel Assembly and Fuel Tube Wall (in)
We 17x17	0.360	0.021	0.496	0.564
We 15x15	0.417	0.024	0.563	0.561
We 14x14	0.400	0.022	0.556	1.232
CE16x16	0.382	0.025	0.506	0.888
CE14x14	0.440	0.031	0.580	0.880
BW17x17	0.377	0.022	0.502	0.451
BW15x15	0.414	0.022	0.568	0.494

Review of the design basis fuel inventory indicates that the largest gap between the enveloping of the fuel rods of a straight fuel assembly and the basket fuel tube inner wall could be 1.23 inches, corresponding to a 14×14 rod array having a minimum rod pitch of 0.556 inch and a minimum rod diameter of 0.40 inch inside a maximum basket fuel cell inside dimension of 8.86 inches. In this evaluation, an assembly with an initial bow of 0.55 inch is permitted to displace an additional 0.68 inch to the full gap displacement of 1.23 inches. A PWR 17×17 fuel assembly with a bow of 0.55 inch

(less than the gap of 0.564 inch, as shown in the preceding table) can still be fit into a MAGNASTOR basket fuel tube. To implement a bow of 0.55 inch into the fuel assembly, the half-symmetry ANSYS model corresponding to a row of fuel rods (Figure 3.8.3-1) is used. The clad is modeled with shell elements (Figure 3.8.3-2). Each grid is modeled using brick elements to maintain the spacing between the fuel rods at the grid (Figures 3.8.3-2). The fuel tube is modeled using brick elements to restrict the lateral motion of the fuel assembly. Each of the fuel rods in the ANSYS model is simply supported at each end. A static force is applied to the ANSYS model at the grid nearest the axial center to develop a 0.55-inch lateral displacement. The purpose of the ANSYS model and solution is to provide the coordinates of the fuel clad for the LS-DYNA model. This is accomplished by obtaining a static solution with the ANSYS model, and then using the option to update the coordinates of the nodes based on the displacements from the solution..

Five LS-DYNA models are considered for the 24-inch cask end drop conditions. All models incorporate a bow of 0.55 inch. These cases envelop the range of the cross-sectional moments for the PWR fuel rods and the grid spacing at the bottom of the fuel assembly as summarized in the following Table. Case 5 is used to confirm that the acceleration associated with the 24-inch end drop of the MAGNASTOR system provides bounding stresses.

Case	Fuel Assembly	Lowest grid spacing (inch)	Acceleration definition
1	14x14	60*	45g
2	14x14	33	45g
3	17x17	60*	45g
4	17x17	33	45g
5	17x17	60*	25.3g

* The 60-inch spacing corresponds to the fuel rod configuration with two missing grids at the bottom of the fuel assembly

In all cases, the thickness of the clad was reduced by 120 microns (0.0047inch). Cases 1 through 4 require a separate ANSYS model and LS-DYNA model to represent unique coordinates or boundary conditions (geometry of Case 5 is the same as for Case 3). The LS-DYNA model employs the same nodes and elements as the ANSYS model (with the incorporation of the 0.55-inch bow). Elastic properties are used in the ANSYS model and the bilinear properties are employed in the LS-DYNA model. An initial downward velocity of 136 in/sec (corresponding to a 24-inch end drop for the storage condition) is assigned to all nodes in the model. The deceleration time history is applied to the nodes of the brick elements representing the fuel tube. The side walls

of the fuel tube are restrained in the lateral direction to maximize the effect of the fuel rods impacting the fuel tube side wall.

The LS-DYNA analyses for Cases 1 through 4 were performed for the duration of 0.08 second to capture the response of the fuel after the 0.02 second loading duration. Post-processing each analysis result identifies the maximum shear stress occurring at the shell surface. The maximum shear stress result from LS-DYNA is factored by two to determine the maximum stress intensity.

The following table contains the maximum stress intensity for the five cases.

Maximum Stress Intensity for the Five LS-DYNA Analyses

Case	Maximum Stress Intensity (ksi)	Factor of Safety Against Yield Strength
1	25.4	3.08
2	21.8	3.59
3	41.9	1.86
4	34.7	2.25
5	22.0	3.54

The case using the 60-inch spacing in conjunction with the minimal cross-section (Case 3) is identified as the bounding case. All stresses were shown to be less than the yield strength.

The results confirm that high burnup PWR fuel with a maximum distance of 60 inches from bottom to the first grid will remain structurally adequate for the storage design basis cask end drop load conditions.

Figure 3.8.3-1 Overall Model Plot for a Typical PWR Fuel Assembly

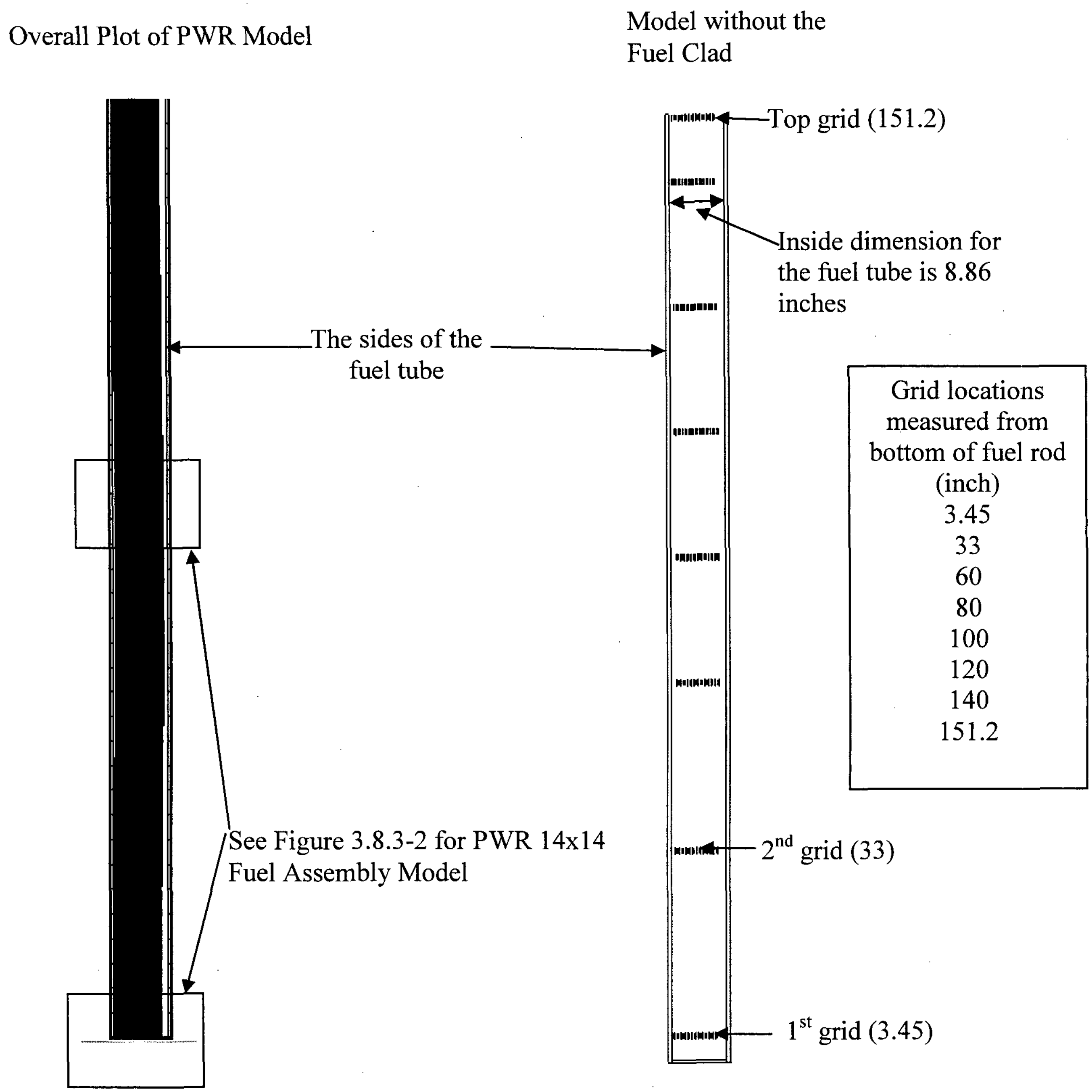
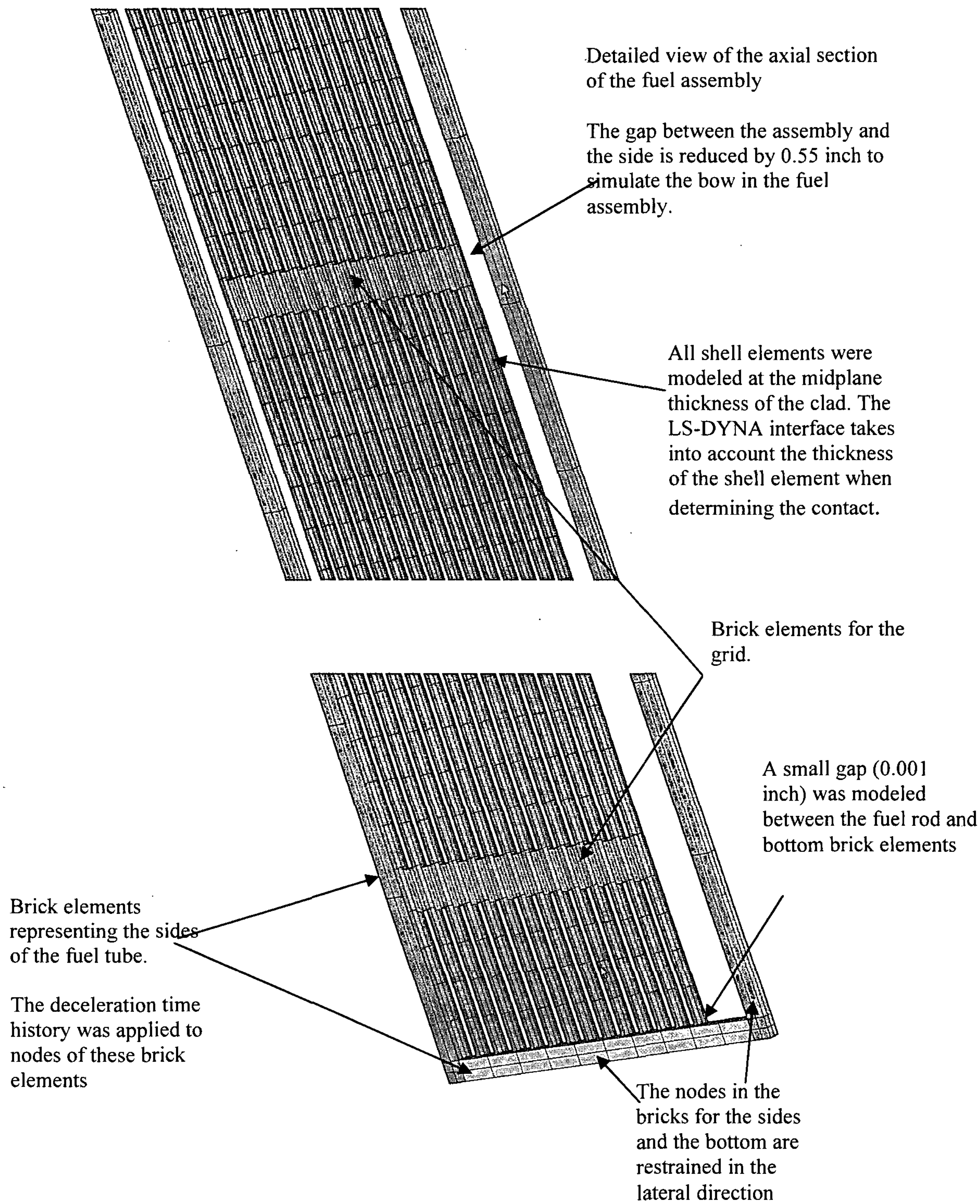


Figure 3.8.3-2 Detailed View of the PWR 14×14



The description of the side drop for the fuel assembly will be included in a new Section 3.8.4, as follows.

3.8.4 Side Drop Evaluation

The basket side drop configuration is evaluated using a uniformly applied 60g's along the length of the basket. This significantly bounds the accelerations developed in the concrete cask tip-over accident in which the accelerations vary from near-zero value at the point of rotation to a maximum acceleration reported in Section 3.7.3.7 of 26.6g's at the top of the basket. The analyzed bounding fuel rod length of 60.0 inches envelops all fuel types and includes the condition with a missing support grid in the fuel assembly. During a side drop, the maximum deflection of a fuel rod is based on the fuel rod spacing of the fuel assembly. Assuming a 17×17 array (fuel assembly with the maximum number of rods), the maximum fuel rod deflection, including the 120-micron oxide layer, is:

$$(17\text{-}1) \times (0.496\text{-}0.36+2\times120\times10^{-6}\times39.37) = 2.33 \text{ in.}$$

The side drop loading is evaluated for three fuel rods, which corresponds to the limits of the stress modulus Z (ratio of the cross-sectional moment of inertia to the maximum radius to relate the maximum fiber stress (S) to the bending moment (M), S=M/Z) and the maximum span, as shown in the following table.

Case	Rod diameter (inches)	Clad Thickness (inches)	Z (in^3) (10^{-3})	Span (inches)
CE14x14	0.440	0.031	3.18	16.8
WE15x15	0.417	0.024	2.20	26.2
WE17x17	0.360	0.0205	1.33	20.6

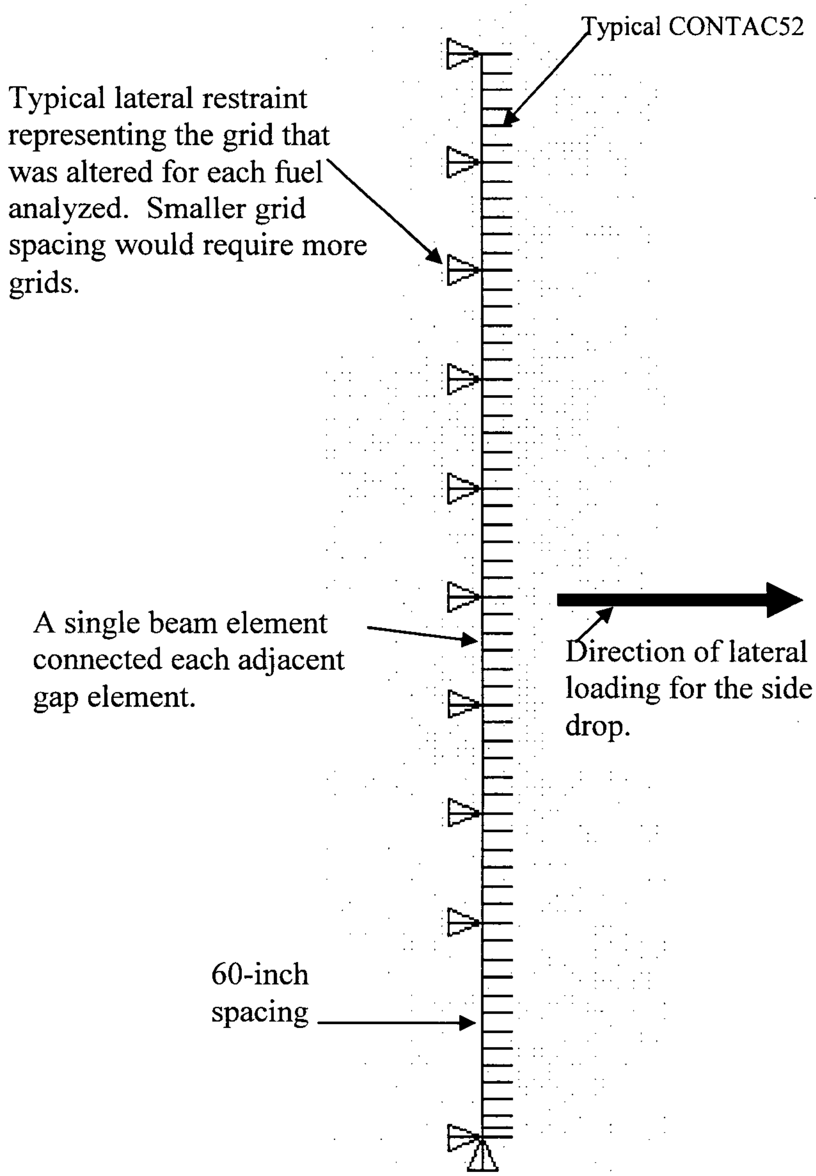
ANSYS is used to perform a static analysis with a lateral loading of 60g. The model is shown in Figure 3.8.4-1. The fuel rod is modeled with beam elements, and the properties for the fuel clad take into account the reduction of the outer radius by 0.0047 inch (120 microns). The density of the beam element material was based on the zircaloy clad (0.237 lb/in^3) and the pellet density (0.396 lb/in^3). The lateral constraints show the location of the grids used in the model, and the distance from the end of the fuel rod to the first support is 60 inches. The analyses confirm that the rod lateral displacement is 2.33 inches, which results in the fuel rod being supported with the 60-inch distance between adjacent grids. Therefore, the location of the unsupported span along the fuel rod is not significant. The spacing for the adjacent grids is shown in the preceding table.

To represent the maximum gap of 2.33 inches, which the fuel rod can displace in the side drop, CONTAC52s were modeled at each node. The gap for each CONTAC52 was set to 2.33 inches to limit the lateral displacement of the fuel rod to 2.33 inches. The gap stiffness for each CONTAC52 was defined to be 10^6 lb/in, which simulates the resistance of the basket to the lateral motion of the fuel rod. The lateral flexural stiffness of the fuel rod is considered to be insignificant compared to the stiffness of the basket. The effect of this stiffness, whether larger or smaller, would not influence the maximum stress. The maximum stress in the fuel rods is shown in the following table, and the allowable is the yield strength at 752°F (69.6 ksi).

Case	Maximum Stress (ksi)	Margin of Safety Against Yield Strength
CE14x14	37.1	+0.88
WE15x15	48.1	+0.45
WE17x17	46.3	+0.50

This confirms that the PWR fuel rod subject to high burnup will remain intact for a 60g side drop condition, which bounds the tip-over accident condition.

Figure 3.8.4-1 ANSYS Model for the PWR Fuel Rod High Burnup Condition



Section 3.10.2.3.2 Thermal Stress Boundary Conditions

3-4 Draft RAI

Explain why the same temperature conditions for the PWR fuel basket thermal stress analysis finite element model in Section 3.10.1.3.2 are also implemented for the BWR fuel basket.

The inherent configuration differences in the PWR and BWR baskets are unlikely to result in the same temperature boundary conditions for the thermal stress analyses. It is unclear whether the temperature boundary conditions have mistakenly been transcribed in the SAR. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. Accurate and complete information should be provided to meet the 10 CFR 72.11(a) requirements.

Summary of Technical Discussion

NAC indentified that the thermal expansion stresses are driven by the thermal gradients in the model. It is adequate to define the bounding thermal gradients for both PWR and BWR thermal stress evaluation with the same temperature values that are greater than the actual values for both basket configurations. It is not necessary that a separate thermal gradient be used for each basket configuration. Discussion with the staff resulted in understanding of the adequacy of analyses, with the request for clarification to be added to the current text.

Proposed Resolution
Category 2

NAC has reviewed current SAR text and provides the proposed clarification below.

Draft SAR Text Change

Proposed text: page 3.10.1-4
"...... As shown in the following table, a total of five cases of temperature boundary conditions are ***defined that envelop*** the maximum temperature gradients (ΔT), in the axial and radial directions of the basket for all conditions of storage and transfer."

Proposed text: page 3.10.2-4
"...... As shown in the following table, a total of five cases of temperature boundary conditions are ***defined that envelop*** the maximum temperature gradients (ΔT), in the axial and radial directions of the basket for all conditions of storage and transfer. ***It is noted that these temperatures are the same values that have been used for the PWR basket thermal expansion stress analyses. These BWR basket temperatures are***

conservative for calculation of thermal expansion stresses in the BWR basket as the PWR heat load is 2.5 kW greater the BWR heat load. The thermal stress analysis is performed……"

Section 3.10.2.3.2 Thermal Stress Boundary Conditions

3-5 Draft RAI

Clarify the bases for assigning (1) a higher temperature at the outer radius than that at the center line of the basket (Case 4, D>C), and (2) a higher temperature at the axial end than that at the interior of the basket (Case 3, C>A), for the same thermal boundary temperatures shown on pages 3.10.1-5 and 3.10.2-4 for the respective PWR and BWR baskets.

The temperature boundary conditions cited above appear to be contradictory to the thermal condition laws. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. Accurate and complete information should be provided to meet the 10 CFR 72.11(a) requirements.

Summary of Technical Discussion

NAC identified that Case 3 and Case 4 correspond to the storage condition in which the heat is being transferred from the fuel region by convection.

In Case 4, the model corresponds to the bottom 47 inches of the basket, so that the axial end of the basket is the bottom of the basket nearest the bottom canister plate. The relationship of the temperatures at the bottom (D and C) can be understood by reviewing the manner in which the fuel heat is rejected from the basket. As the helium rises in the basket region, its temperature is increased. This heat is rejected to the canister shell as the helium flows down the inside of the canister wall and, as a result, the helium temperature at the bottom next to the canister shell is reduced from B to C. As the canister gas flows along the bottom of the canister, it is also cooled to some extent since the canister bottom plate rests on a cooler pedestal. It is noted that the fuel heat at the bottom of the basket is small relative to the higher sections of the basket. Consequently, since the helium is cooled along the bottom canister plate, its temperature is reduced. This accounts for the temperature at D (the outer radius in Case 4) being lower than the temperature at C (the center of the bottom plate in Case 4).

The model for Case 3 represents the top 47 inches of the basket. Since the fuel heat is being rejected by convection of helium, its temperature must increase as the helium rises to the top of the basket. For this reason, the temperature at C (at the top center of

the basket) is larger than the temperature at A (at the center, 47 inches below the top of the basket).

Proposed Resolution
Category 1

The technical discussion as summarized above provided acceptable clarification.

Draft SAR Text Change

Change to the SAR text is not required.

Section 3.10.8

3-6 Draft RAI

Provide a sufficient description, in Section 3.10.8, of the LS-DYNA periodic basket models for evaluating strain performance of the pin-slot connections, if the cases considered are different from those reported in Section 3.10.6 for the basket geometric stability evaluation. Add to the description for the cases with maximum plastic strains the load factor, which is a multiple of the design basis tip-over deceleration.

The strain performance at the most critically stressed locations appears to be based on a different set of LS-DYNA analyses from the geometric stability evaluation. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. Accurate and complete information should be provided to meet the 10 CFR 72.11(a) requirements.

Summary of Technical Discussion

The models used in SAR Section 3.10.8 are constructed using the same modeling methodology as used in the models presented in SAR Section 3.10.6, with the pin-slot connection associated with the largest shear load modeled with a finer mesh (SAR Figures 3.10.8-2 and 3.10.8-4).

The unfiltered acceleration time history at the top of the basket (Figure 3.7.3-3) is conservatively used in the BWR evaluation. The maximum filtered acceleration is 26.4g and the unfiltered acceleration at the same time is 32.3g , which results in a load factor of 1.22 (32.3/26.4). The unfiltered acceleration with a factor of 1.1 is used for the PWR analysis for additional conservatism (The resulting load factor for PWR is 1.1×1.22, or 1.34).

Proposed Resolution
Category 2

NAC agrees to edit SAR Sections 3.10-6 and 3.10-8 providing clarification addressing load and safety factors.

Draft SAR Text Change

Proposed text: Section 3.10.8, page 3.10.8-1

The three-dimensional half-symmetry finite element models for the 0° basket orientation, as shown in Figure 3.10.8-1 (BWR) and Figure 3.10.8-3 (PWR), are used for the evaluation. These models are associated with the maximum shear forces at the pin-slot connections, based on the quasistatic analyses for BWR and PWR baskets for the tip-over accident as documented in Section 3.7.2. ***The models are constructed using the same modeling methodology as used for the models presented in Section 3.10.6***. To more accurately solve for the stress/strain at the pin-slot connections, the pin-slot connection associated with the largest shear load is modeled with a finer mesh, as shown in Figure 3.10.8-2 (BWR) and Figure 3.10.8-4 (PWR). The LS-DYNA program is used to perform transient (time history) analyses to simulate the side impact condition of the cask tip-over accident. The unfiltered acceleration time history at the top of the basket (Figure 3.7.3-3) is conservatively used in the BWR evaluation. ***The maximum filtered acceleration is 26.4g and the unfiltered acceleration at the same time is 32.3g , which results in a load factor of 1.22 (32.3/26.4).*** The unfiltered acceleration with a factor of 1.1 is used for the PWR analysis for additional conservatism ***(The resulting load factor for PWR is 1.1×1.22, or 1.34).*** The calculated maximum plastic strains at this pin-slot connection are shown in the following table. See Figure 3.10.8-5 and Figure 3.10.8-6 for locations of the maximum strains in the pin and the tube slots, as well as the time history of the maximum plastic strain, for the BWR and the PWR basket, respectively.

NAC Proprietary Calculation No. 71160-2020 Rev 0

3-7 <u>Draft RAI</u>

Verify on Page E.3 that the angular acceleration is properly prescribed as a boundary condition for the TSC-basket finite element model.

The calculation considered an angular acceleration of 0.279 inch/sec^2 that appears to be dimensionally incorrect and it's unclear how the ANSYS "DOMGA" command can result in an inertia load of 60g at top of the canister. Accurate and complete information should be provided to meet the 10 CFR 72.11(a) requirements.

Summary of Technical Discussion

The units for DOMEG in ANSYS for this model is g's/inch. The units of g's for acceleration is used since the density is defined input as pounds/in^3. The units reported in the proprietary calculation represent a typographical error and should be reported as g's/inch. It is noted that the value applied in the analysis calculation is correct and does not require revision.

Proposed Resolution
Category 1

Teleconference discussion resolved issue as documented in the above summary.

Draft SAR Text Change

SAR text revision is not required.

Chapter 4.0 Thermal Evaluation

Section 4.1 Discussion

4-1 Draft RAI

Demonstrate in the SAR that the preferential loading scheme in the PWR basket will result in bounding peak cladding temperatures over the uniform loading scheme for normal storage conditions.

The SAR requests both a preferential loading scheme with 1.2 kW fuel assemblies in certain zones or a uniform loading of 0.959 kW. However, the thermal analyses and calculated temperatures appear to only address the preferential loading case. In addition, the SAR implies that preferential loading provides enhanced convection. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC acknowledged staff comment and stated that the thermal comparison of the preferential and uniform loading configurations were presented in calculation 71160-3005 transmitted to the NRC in October 2004. It was noted that the review staff did not have a record of this calculation. A duplicate copy of the referenced calculation has been provided.

In Calculation 71160-3005 Revision 0, there are two analyses performed to compare the thermal response of the uniform loading configuration to that of the preferential loading configuration. The peak clad temperature for the preferential loading configuration is 6°F higher than the peak clad temperature for the uniform loading configuration. Following the time that these analyses were performed design basis heat load was reduced from 40 kW to 35.5 kW for the PWR basket configuration and model enhancements were made to hydraulic resistance and the TFR – concrete cask annulus turbulence model. All changes made to the PWR thermal model influence system response and do not introduce localized change influencing the comparison of the uniform loading configuration verses preferential loading configuration.

Proposed resolution
Category 2

NAC has reviewed the current SAR and provides proposed clarification below.

Draft SAR Text Change
Proposed text: Section 4.4.1.1, page 4.4-9

".... The heat generation values specified in Figure 4.1-1 are considered to be the maximum permissible heat generation in each fuel location. ***It is noted that maximum fuel assembly heat load in Figure 4.1-1 is 25% greater than the heat load for the uniform condition. The fuel in the center of the basket in Figure 4.1-1. Zone A, at 0.922 kW is only 4% less than the uniform heat loading at 0.96 kW per assembly. The use of hotter assemblies in the Zone B ring results in slightly more flow in the Zone B region with the higher heat load, but simultaneously present a bounding condition over the uniform loading of the entire basket since the edge of Zone A temperatures are increased by the influence from the higher heat in Zone B. An analysis using a 40 kW preferential loading using a more aggressive annular turbulence model (K-ε) with a reduced flow resistance showed that the preferential heat distribution increased the maximum fuel temperatures by 6°F. With the reduction of the maximum heat load to 35.5 kW, the 6°F difference in maximum fuel cladding temperature will decrease, but will still produce temperatures equal to or greater than the uniform heat load configuration.***

For the BWR fuel Basket, only....."

Section 4.4.1.5 Two-Dimensional Transfer Cask and TSC Model

4-2 Draft RAI

Describe the approach and/or procedure used to calculate the thermal effective properties of the transfer cask.

Page 4.4-19 of the SAR states that the transfer cask is represented by effective properties, but a description of how these properties are obtained is not provided in the SAR. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation, which serves as the basis for approving this cask design. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC acknowledged staff comment and stated that the effective properties have been provided in proprietary NAC Calculation 71160-3020. The TFR cask wall is comprised of four different materials: 1) a carbon steel inner shell; 2) a lead gamma shield layer; 3) a NS4FR neutron absorber layer; and 4) a carbon steel outer shell. The calculation defines Ks and Kp as effective properties in the cask radial and cask axial directions respectively. Heat flow in the radial direction would treat the layers of material as being in series (Ks). For any heat flux in the axial direction, the layers of material would be treated as being in parallel (Kp). Table 6.2-1 in the referenced

calculation shows the results of using the defined geometry and the thermal properties for the different materials used to compute Ks and Kp.

Staff requested clarification to be added to the SAR text addressing the development of the effective properties.

Proposed resolution
Category 2

NAC agrees to incorporate clarification summary.

Draft SAR Text Change
Proposed text: Section 4.4.1.5, page 4.4-19

"…… The transfer cask is represented by effective properties. ***The transfer cask wall is comprised of four different materials: 1) a carbon steel inner shell; 2) a lead gamma shield layer; 3) a NS4FR neutron absorber layer; and 4) a carbon steel outer shell. Effective thermal conductivity for the transfer cask in the radial direction treats the four different cask wall materials as being in series. The effective thermal conductivity for the transfer cask wall in the axial direction treats the four different cask wall materials as being in parallel.*** The model also contains the …."

4-3 Draft RAI

Clarify in the SAR that water is displaced by helium gas during TSC blowdown, in preparation to perform vacuum drying. Update the operating procedures and proposed Technical Specifications to clarify appropriate blowdown requirements, consistent with the thermal analysis.

Page 4.4-19 of the SAR states that conduction helium properties are utilized during the low-pressure drying process. In order to establish a helium environment inside the TSC before vacuum drying is performed, liquid water should be displaced by helium gas. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC identified that the requirement for backfilling the canister with helium during the draining process is currently in Chapter 9, Operating Procedures, Section 9.1.1, step 52.

Proposed Resolution
Category 1

Issue as noted is closed.

Draft SAR Text Change

SAR change is not required

4-4 Draft RAI

Provide a detailed description in the SAR on how the 3-D temperature distribution is conservatively mapped to the 2-D thermal analysis of the TSC and vice versa, considering differences in mesh size, use of homogenized models, and any margins between the calculated temperatures and temperature limits for the cladding. Identify and describe uncertaintities and limitations in the methodology.

Page 4.4.20 of the SAR states that the initial temperature field of the transient evaluation to simulate the helium backfill condition (performed using a 2-D Fluent axisymmetric model) is obtained from the analysis results at the end of the vacuum drying process (3-D Ansys results). Differences in meshing scheme and collapsing of data from 3-D to 2-D may result in erroneous or uncertain temperature fields, which are subsequently used to perform transient calculations. This uncertainty may be acceptable if there is significant margin in calculated temperatures, but it should be described in the SAR. The staff requires this description in the SAR to clearly document the methodology and results of the evaluation that is being approved for cask certification. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC acknowledged staff comment and identified that the details defining the temperature mapping have been provided in proprietary NAC Calculation 71160-3020. Staff stated that they had not reviewed this calculation; however, they requested that a summary of the method be added to the SAR.

Proposed resolution
Category 2

NAC agrees to incorporate the requested clarification.

Draft SAR Text Change
Proposed text: Section 4.4.1.5, page 4.4-20

"..................The initial temperature field of the transient evaluation to simulate the helium backfill condition is obtained from the analysis results at the end of the vacuum drying process (ANSYS results) for the respective heat load.

The Fluent model used to analyze the cool down transient defines the locations at which initial temperatures are required from the ANSYS results. For each node in the Fluent model, there are 8 node points in the circumferential direction in the ANSYS 45° symmetry model to compute the average temperature for the respective locationl. The ANSYS model employs linear temperature shape functions across each element, so that interpolation between nodes and within an element provides temperatures, which are consistent with the nodal temperature in the ANSYS results. The peak temperatures, which occur at the center line of the model are transferred to the respective Fluent node locations as initial temperatures in order to provide an upper bounding initial condition conserving system heat provided to the Fluent model.

The design basis heat load provides bounding......"

4-5 Draft RAI

Provide the following information regarding maximum fuel temperatures for initial vacuum drying conditions. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f):

(a) Justify the maximum fuel temperatures reported in Tables 4.4-5 and 4.4-6. Perform transient calculations (if necessary) including the necessary details in a model which will result in realistic temperatures to justify the values provided in Tables 4.4-5 and 4.4-6.

Sections 4.4.1.5 and 4.4.1.6 of the SAR do not specify how these temperatures are controlled while the flooded TSC is being prepared for drying. These temperatures are used as initial condition to perform vacuum drying analyses. It appears that during the loading phase previous to vacuum drying, the fuel is subjected to heating transient conditions inside the transfer cask. This may result in higher temperatures than the assumed values used in the vacuum drying analysis.

(b) Provide Fluent input and output files and Gambit data base for the thermal evaluation of water phase.

The application provided thermal calculations and input and output files for other phases of loading operations except for these conditions. The staff needs to audit these files to verify that input files were properly prepared and output data was consistently used throughout these different phases.

Summary of Technical Discussion

NAC discussion provided clarification of the system configuration defining the thermal boundaries during system closure and drying operations. The transfer cask and canister are loaded with contents while fully immersed in the spent fuel pool. Following loading and placement of the canister lid the transfer cask is positioned on an in-pool shelf or moved from the pool to a decontamination area depending on specific plant facility design and loading procedures. In both configurations, water is in the canister and in the annulus between the canister and the inner shell of the transfer cask. Water in the annulus between the canister and transfer cask inner shell continues to circulate and reject heat. This system configuration, either on the pool shelf or in the decontamination service area is maintained through lid welding, canister draining with helium back fill, vacuum drying, and final helium back fill, port cover welding and leakage testing. Therefore, for the period of time during service operations prior to system draining thermal performance is representative of the steady state condition with water in the canister and circulation in the annulus between the canister and transfer cask.

The requested proprietary NAC Calculation 71160-3007 Rev. 3 is being provided under separate cover.

Proposed Resolution
Category 3

It is anticipated that the discussion provided during the teleconference and summarized above with the submittal of the requested proprietary calculation will close this issue.

Draft SAR Text Change

SAR change is not required.

4-6 Draft RAI

Update the SAR and perform additional calculations (if necessary) to obtain mesh-independent results for the cases of maximum decay heat.

Based on a staff's model using a much finer mesh (e.g., staff's Fluent 3-D model based on about 330000 cells versus applicant's ANSYS 3D model based on about 14000 elements), it appears that the SAR calculations for vacuum drying may not be mesh-independent, and may underestimate cladding temperatures. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC identified that minor difference in analysis results may be expected when comparing one modeling methodology with respect to a different modeling methodology. Mesh sensitivity is not expected to be a driving issue relative to the calculation of maximum temperature values which is further highlighted by the results from a conservative analysis based on adiabatic boundary conditions for both ends of the basket. NAC acknowledged the staff comment and committed to provide clarification.

Proposed Resolution
Category 2

NAC is providing additional text to Section 4.4.1.5 defining modeled element performance and boundary condition details that support the arguments that the thermal analyses are conservative in their calculation of maximum temperature results.

Draft SAR Text Change
Proposed text: Section 4.4.1.5, page 4.4-20

".....shock to the transfer cask system. Maximum temperature on the canister outer diameter from the water phase analysis is applied to the canister surface for each heat load.

The modeled boundary conditions implemented to calculate maximum basket and fuel cladding temperatures are summarized in the following discussion. Figure 4.4-17 shows the three dimensional ANSYS model for the vacuum evaluation. In a typical fuel tube, the cross section of the fuel has six or more elements. In the finite element method embedded in ANSYS the temperature across each finite element is allowed to vary in a linear manner. With the heat generation being uniform in any specific slot, the temperature distribution will be approximately parabolic. Using six linear segments to represent the approximate parabolic behavior is more than needed to provide sufficient accuracy of the temperature distribution in the fuel region. The model shown in Figure 4.4-17 also shows a detailed view of the corner of the tube. The tube is shown to have two elements in the thickness to represent the conduction in the tube wall. Having the linear temperature distribution in each element allows the tube wall thickness variation to be nonlinear even though only conduction through the wall is modeled. The detailed figure also shows a gap between each corner in the model which prevents adjacent tubes from conducting heat directly to adjacent tubes. It is further noted that the neutron absorber is explicitly modeled with effective properties. The through thickness direction treats the composite material in series to account for potential gaps in the materials comprising the absorber. The axial direction of the absorber is represented by the materials of the absorber being in parallel. This orthotropic representation incorporated gaps

associated with the absorber assembly. Figure 4.4-16 shows that the fuel region is represented by 15 axial divisions, which provides detail representing the axial power distribution. It is noted that both ends of the three dimensional ANSYS model are adiabatic forcing all heat rejection to the sides of the model. The adiabatic end condition introduces additional conservative margin since it neglects any heat rejection to the ends of the canister by radiation and conduction. At the bottom of the canister the hotter fuel is in direct contact with the cooler canister plate and massive transfer cask doors. At the top of the canister radiation to the canister lid is neglected and the lid's ability to reject heat through approximately 28 square feet of a flat heated lid surface facing upwards is also neglected. Radiation from the outer basket surface to the canister inner surface is included by computing the radiation matrix taking into account the emissivities of each surface. The calculation of the radiation matrix is broken into three regions in which the basket surface directly faces the inner canister surface. This particular configuration for a radiation matrix calculation is not complicated by trying to determine what surfaces are hidden. With the inclusion of the conservative end condition and the use of a minimum of six elements in a tube cross section, the model is considered to be adequate for the evaluation of the basket in the vacuum condition.

Effective properties for the PWR and BWR ….."

Section 4.4.3 Maximum Temperatures for PWR and BWR Fuel Configurations

4-7 <u>Draft RAI</u>

Provide a bounding thermal calculation and SAR methodology that includes the effect of the maximum site elevation on the atmospheric pressure and resultant heat transfer. Describe in the SAR any additional calculations that a cask user must perform in order to demonstrate that MAGNASTOR can be operated safely at site elevations higher than the bounding calculation.

The site elevation where the MAGNASTOR is deployed may have an impact on the operating pressure of the concrete cask. This in turn will have a direct impact on convective heat transfer properties and calculated peak cladding temperature. The staff has found that lower atmospheric pressure can significantly increase temperatures for certain cask designs. This information is needed to assure compliance with 10 CFR 72.11, 72.24(d), and 72.236(f).

<u>Summary of Technical Discussion</u>

NAC acknowledged the staff comment and stated that the calculations performed in the SAR were based on sea level conditions. NAC committed to provide clarification in the SAR addressing this issue.

Proposed Resolution
Category 2

Subsequent to the teleconference discussion of the Draft RAI it was noted that the maximum site elevation for US commercial nuclear power plants is 1100 feet, which is the site elevation of Wolf Creek. It is further noted that the design basis average annual ambient temperature has been defined as 76°F, Miami, Florida. As a proposed ISFSI site moves north the average annual ambient temperature decreases. Evaluating design basis thermal performance at a 1000 foot elevation and 76°F resulted in maximum temperatures 9°F higher than the design basis standard sea level analyses. It is noted that the average annual temperature for the Wolf Creek site is 55°F, 21°F cooler that the design basis calculations. When one considers elevation, site specific ambient temperature and calculated thermal margins relative to maximum system allowable limits, the MAGNASTOR system can be safely operated at US commercial nuclear power plant sites. A change to the SAR is proposed to highlight the need to address site specific conditions for average annual temperature and elevation.

Draft SAR Text Change
Proposed text: Section 4.4.3, page 4.4-23

".....The maximum component temperatures for the normal conditions of storage for the PWR and BWR design basis fuel are shown in Table 4.4.3. ***It is noted that these system thermal performance results are based on an average annual ambient temperature of 76°F at sea level pressure and standard air density properties. Site specific conditions are to be evaluated to assure thermal margins are maintained for steady state storage conditions at the intended MAGNASTOR ISFSI site.***

As shown in Figure 4.4-14......."

Chapter 6.0 Criticality Evaluation

6-1 Draft RAI

Update the SAR as necessary to assure that the tolerances applied in the criticality analysis bound the design tolerances of the absorber plates and fuel tube thickness.

The criticality analysis includes tolerances on the dimensions of the absorber plates and fuel tubes to derive the maximum reactivity configuration of the basket. However, staff is unable to verify, based upon the information currently supplied in the SAR, that the tolerances used in the criticality analysis are the same as, or bound, the design tolerances for the absorber plates and fuel tube thickness. Specification of the requested tolerances in the SAR, particularly in the technical drawings, would enable confirmation of the bounding nature of the tolerances used in the criticality analysis. The tolerances in the analysis should be based upon, or bound, the design tolerances. This information is needed to confirm compliance with 72.236(c).

Summary of Technical Discussion

NAC acknowledged the staff comment and provided a discussion of tolerance variables influencing criticality evaluations and identified how they were included in the analysis. The SAR evaluations shown in Section 6.7 of the MAGNASTOR SAR rely on design basis tolerances. In particular, the fuel tube is conservatively evaluated at a thickness tolerance of ±0.03 inch, while the absorber plate is evaluated for a thickness tolerance of ±0.005 inch. The actual tolerance on the fuel tube is -0.01,+0.03 inches per the ASTM standard on the ASME SA537, Cl 1 tube material specified in SAR tube drawings 71160-551 and 71160-591 (ASME SA537 refers to ASTM A20/A20M for plate tolerances). To clarify the tolerances used in the analysis and to correlate the values to the SAR technical drawings, the neutron absorber drawings 71160-571 (PWR) and 71160-572 (BWR) will be revised to remove the nominal thickness specifications for the absorber and replace them with 0.125±0.005 inch for the PWR absorber (77160-571) and 0.100±0.005 inch for the BWR absorber. As the fuel tube thickness is controlled by the plate specification, no tolerances are added to the tube thickness. The criticality analysis text in Section 6.4.2.1 ("Fabrication Tolerances") is revised to explicitly list the fuel tube and absorber thickness tolerances used in the analysis.

Proposed Resolution
Category 2

Provide editorial change to SAR text and revision to drawings 71160–571 and 71160-572 adding the absorber tolerance of ±0.005 inch .

Draft SAR Text Change
Proposed test: reference SAR Section 6.4.2.1, page 6.4-2

" ....tube and neutron absorber width and thickness have the potential to significantly affect the size of the tube opening and developed cell locations. ***Tube wall thickness is conservatively evaluated for a tolerance of ±0.03 inches (versus a tolerance of -0.01,+0.03 inches from the ASTM standard for the specified plate material) while the neutron absorber is evaluated at a design tolerance of ±0.005 inches***. The side and corner weldments provide structural support ...."

6-2 Draft RAI

Provide an analysis with the minimum fuel tube orthogonal pitch (center-to-center spacing between adjacent fuel locations) that results from any permanent deformation/collapse arising from accident conditions.

The criticality analysis currently uses the minimum fuel tube orthogonal pitch specified in the Technical Specifications. Use of the pitch in the Technical Specifications assumes there is no permanent deformation. The SAR indicates, however, that there is some permanent deformation/set that results from the analyzed accident conditions. In some locations this deformation is stated to be insignificant (e.g., Section 6.3.2); however, there is no quantitative justification for this statement. The criticality analysis should include calculations that use a minimum pitch that accounts for the permanent deformation due to the accident conditions; this pitch would be somewhat smaller than the pitch in the Technical Specifications, accounting for the permanent deformation resulting from accident conditions, as determined by the structural analysis. The criticality analysis should, at a minimum, include calculations for the PWR and BWR contents that have the least margin to the USL (for each basket configuration – 37 PWR, 87 BWR, and 82 BWR assemblies), and show that the USL will not be exceeded for these cases even while accounting for the affects of fuel tube/basket deformation. System contents should be modified as necessary for those cases where the currently proposed contents specifications result in the USL being exceeded. The applicant should demonstrate that the deformation (the resulting minimum pitch) used in the calculations is supported by/derived from the structural analysis. This information is needed to confirm compliance with 10 CFR 72.236(c).

Summary of Technical Discussion

NAC acknowledged the staff comment and provided clarification addressing local basket plastic displacement and the bases leading to the conclusion that the calculated plastic displacement did not impact criticality safety.

Structural evaluations shown in Section 3.7.1.2 (PWR) and Section 3.7.2.2 (BWR) determine maximum permanent (plastic) displacements of 0.008 inch (PWR) and 0.004 inch (BWR). Illustrations of the displacement are shown in Figure 3.7.2-1 (PWR) and 3.7.2-2 (BWR). [Note: Figure 3.7.2-2 has been revised per the "Proposed Resolution" section of this response.] The permanent deformation is limited to the local region where the tip-over load and canister shell displacement boundary permit the development of this calculated maximum plastic strain. Therefore, the location of the fuel assemblies does not change compared to one another, as the assemblies are held in their preaccident location by the sections of the fuel tubes that did not undergo plastic deformation. The plastic deformations for all tubes are over a factor of two smaller than the 0.02-inch tolerance evaluated for the diagonal width (interface width). The tolerance studies showed no statistical change in k_{eff} ,(see Sections 6.7.3 and 6.7.6), as the result of the tube cross-section reduction of 0.02 inch. Revisions in models for the permanent set in the tubes are, therefore, not necessary, as they will not provide statistically significant information or changes in the results.

Proposed Resolution
Category 2

NAC will review the current SAR text and provide additional discussion and clarification on the acceptability of the current criticality analysis relative to tube plastic displacements. It is noted that during the review of the structural analysis investigating the BWR tube response to the tip-over accident, significantly conservative loading had been applied to the BWR model. Revising the BWR analysis for the actual calculated loading results in plastic displacements similar to the PWR tubes in the range of 0.004 inch. Note that BWR data currently shown on SAR page 3.7-38 and in Figure 3.7.2-2 will be replaced by updated structural results that are consistent with the previously reviewed BWR basket/tube models and only require revised SAR descriptions.

Draft SAR Text Change

Proposed text: Section 6.3.2, page 6.3-3.
"Fuel assembly and basket will retain their structure and will not show any significant permanent deformation during normal conditions, off-normal or accident events. ***Per Sections 3.7.1.2 and 3.7.2.2, hypothetical tip-over analysis, the maximum permanent set across the diagonal of the fuel tube is less than 0.01 inch. This represents less than one-half the tolerance evaluated on the fuel tube interface width in Sections 6.7.3 and 6.7.6 and shown to be statistically insignificant (i.e., no statistically significant conclusion can be drawn from the analysis). The tube deformation, therefore, has no resolvable effect on system reactivity or allowed payload configurations."***

Figure 3.7.2-2 will be revised to show the BWR Maximum Diagonal Displacement After Impact of 0.004 inch.

6-3 Draft RAI

Clarify whether Non-Fuel Hardware (NFH) can be loaded into the instrument tube of PWR assemblies and update the criticality analysis as necessary.

There are statements in the SAR (e.g., the middle of page 6.7.2-1) indicating that NFH can be loaded into the instrument tube of PWR assemblies. However, the sample WE17H1 input does not include NFH in the instrument tube. The statements in the SAR and the analysis and the contents specifications in the proposed Technical Specifications should be consistent, with the analysis considering the most reactive conditions. This information is needed to confirm compliance with 10 CFR 72.236(a).

Summary of Technical Discussion

Analysis in Chapter 6 allows the option of loading NFH into either the instrument tube OR guide tube structure. As the analysis evaluates the effect of replacing the borated water moderator by an inert material, the evaluation in Chapter 6 relies on models containing the material replacement in the larger number of guide tubes (e.g., a Westinghouse 17×17 assembly contains 24 guide tubes and one instrument tube). This configuration bounds the single instrument tube material replacement.

Proposed Resolution
Category 2

NAC will revise SAR text to clarify NFH loading of instrument tubes.

Draft SAR Text Change

Proposed text: Section 6.7.1, page 6.7.1-1
"…..the fuel rod lattice filling in the remaining space. Nonfuel assembly inserts are modeled by replacing the interior material definition of the guide [**delete-'*and instrument*'**] tubes by zirconium alloy. By using a zirconium-based alloy in the tubes, no credit is taken for any remaining absorber properties of the rods. ***Modeling the nonfuel insert in the guide tubes bounds a configuration with nonfuel material loaded into the instrument tube active fuel region, but not guide tubes, as assemblies contain a single instrument tube versus multiple guide tubes.***"

Proposed text: Section 6.7.2, page 6.7.2-1
"…under various conditions. Evaluated are a dry-pellet-to-clad gap condition, a flooded-pellet-to-gap condition (with and without soluble boron in the gap), and nonfuel hardware insertion into the guide **[delete '*and instrument*']** tubes."

Proposed text: Section 6.7.2, page 6.7.2-2
"As illustrated in Table 6.7.2-2, the effect of the insertion of nonfuel hardware into the active fuel elevation of the guide **[delete '*and instrument*']** tube varied by fuel type."

For consistency with the criticality evaluations and the content description in Chapter 1, the technical specification Table 2-1 (Chapter 13B), item C, is revised to clarify that components may not be present in the active fuel region of instrument tube and guide tubes simultaneously (added text in italics):

Proposed Text: Section 13B, page 13B-2
"C. PWR UNDAMAGED FUEL ASSEMBLIES may contain a flow mixer (thimble plug), ***instrument thimble***, a burnable poison rod assembly, or a control element assembly consistent with Table 2-2. ***Nonfuel hardware may be located within the active fuel elevation of either guide or instrument tubes. Nonfuel hardware must not be located in the active fuel elevation of guide and instrument tubes simultaneously.*** Assembly lattices not containing the nominal number of fuel rods specified ……"

6-4 Draft RAI

Justify the inclusion of the data that was added to the benchmark correlation analyses in the current SAR, and provide the technical basis (e.g., method and criteria) used to include or exclude potential data in the correlation analyses.

The NRC staff requested in the previous review (see letter dated April 7, 2006, question 6-6) that the applicant revise its benchmark analysis because the trend in the Energy of the Average Neutron Lethargy Causing Fission (EALCF) appeared to artificially raise the USL at higher EALCF energies. There were three data points at the higher EALCF energies which seemed to cause this artificial rise. While these data points were removed (from the EALCF and the other parameter trend analyses), several data points were introduced into the correlations that were previously not included. The explanations provided to date by the applicant do not provide a clear basis for this change (i.e., the addition of these points to the correlations) and appear to be inconsistent with each other. For example, the information supplied as part of the application resubmittal indicates that the additional data was not considered at all in the USL correlations previous to the second RAI response (seemingly contrary to the applicant's email dated November, 28, 2006) due to engineering judgment regarding the acceptability of data for the various parameter correlations. The subsequent addition of the data was stated to be a result of removing engineering judgment from

the analysis. However, engineering judgment is needed to determine those experiments that are most applicable to the cask system analysis and acceptable to include in a benchmark analysis as well as the analyses of particular trends in the data. Previously, the newly added data to each parameter correlation were determined to be not acceptable; however, they have now been added to the parameter correlations. An example of this change in the parameter correlations is SAR Figure 6.7.7-6 for the soluble boron concentration. Several data points were added that had not previously been a part of the trend analysis for this parameter. Staff notes that the descriptions of the benchmark experiments (represented by the added data points) did not include discussion of soluble boron. Another example is SAR Figure 6.7.7-8 for Boron-10 plate loading. Staff notes that there are several benchmark experiments that do not use different absorber plate materials (including plate materials that do not rely on Boron); their appropriateness for use in benchmarking the MAGNASTOR criticality analysis with respect to Boron-10 plate loading is questionable. The applicant should provide a technical justification for this change to all the affected parameter correlations, ensuring that each correlation uses benchmark data appropriate for the respective parameters. This information is needed to confirm compliance with 10 CFR 72.124(a).

Summary of Technical Discussion

Discussion of the following material was addressed during the teleconference, with the conclusion that NAC would provide technical clarification with the response summary.

Details and clarification of the material presented are provided as follows.

As stated in SAR Section 6.5.2, all correlation analysis is based on 183 data-points with the exception of cluster spacing. The 183 data points represent the complete list of 186 critical experiments listed in Section 6.7.7 minus the three high lethargy points requested to be removed by NRC review staff. All critical benchmarks employ square pitch lattices of low enriched (5 wt % ^{235}U max.) UO_2 rods (^{235}U fissile material) in light water to make them applicable to the MAGNASTOR system. For cluster space trending, the single fuel cluster experiments were eliminated, reducing the total to 137 data points.

All experiments contain sufficient information and are applicable to benchmarking code performance against enrichment, fuel rod pitch, fuel pellet outer diameter, fuel rod outer diameter, H/U ratio and average neutron lethargy. Questions on applicability of experiments, therefore, are limited to soluble boron and absorber plate loading.

Soluble Boron

As soluble boron requirements in the system range from 0 ppm (BWR storage and all transport analysis) to 2500 ppm (current PWR maximum listed value), all 183 data points are relevant and appropriate for soluble boron trending and USL limits. Additional discussion is included in the draft RAI 6-5 response as to system effects of excluding data from the correlation analysis (i.e., making engineering judgments on the validity of the high soluble boron data and the applicability of the 0 ppm data). The result of the RAI 6-5 discussion is that:

- Given the low correlation coefficient of the data, modification in the number of data points does not result in a lower USL for soluble boron controlled systems than the one employed in the MAGNASTOR analysis.
- Limiting the number of data points by removing the three high boron content points increases the USL.
- There is a slight (Δk 0.002) reduction in the 0 ppm soluble boron USL when eliminating the majority of 0 ppm data. At 1500 ppm, the reduced data set USL is similar (0.9371 versus 0.9372) or higher than the USL employed in the MAGNASTOR analysis. (Note that the reduced soluble boron USL would not be applicable to the BWR system as it is designed for 0 ppm and should be based on the 0 ppm experimental data.)

Absorber Plate Loading

MAGNASTOR absorber sheets are designed at minimum effective areal densities of 0.027 to 0.036 g $^{10}B/cm^2$. For use in the storage application, the correlation should (and does) cover this range. For transport evaluation, the potential exists for active fuel to be located above the absorber sheet (due to movement of the active fuel as a result of the top accident drop) requiring a no (0) absorber configuration to be bounded. Design changes for lower reactivity fuel may also allow lower absorber density than currently employed, and it was the NAC technical approach to not require the submittal of new bias calculations under those conditions. The trending analysis presented in the SAR, therefore, employed all 183 data points to cover the range of 0 to 0.067 g $^{10}B/cm^2$. As part of the bias/trend calculations, NAC evaluated a reduced data set that removes the experiment sets where no boron-based absorber plates are present, while retaining no absorber plate cases for the experiment sets where subcases contain the plates. This resulted in a reduced set of 72 data points. As shown in Table 6-4 that follows, there is no safety effect of reducing the number of data points. The correlations for either 183 or 72 data points have linear correlation coefficients < 0.1 (which implies that 99+% of the data have no correlation), with minimum USLs of 0.9381 (for 183 points) and 0.9371 (for 72 points) for a Δk of 0.001. The use of the lower number of data points would not affect allowed enrichment calculated for the system.

Table 6-4 USL Calculations for Absorber Loading

# Points	R^2	R	Low		AOA Range		High	USL Limit				USL Low	USL High
183	0.00006	0.008	0	<=	X	<=	0.067	0.9382	-	1.37E-03	X	0.9381	0.9382
72	0.00580	0.076	0	<=	X	<=	0.067	0.9371	+	9.96E-03	X	0.9371	0.9377

Conclusion

All evaluations, with the exception of cluster rod spacing, were based on the complete 183 data point set. This data is appropriate for the MAGNASTOR System analysis.

Proposed Resolution
Category 3

No further information is required in the SAR to demonstrate compliance with regulatory guidance.

Draft SAR Text Change

SAR text revision is not required.

6-5 Draft RAI

Justify the validity of the trend evaluated for the soluble boron concentration parameter.

Staff notes that there is a significant area of the curve for which there is no data to support the trend determined for the soluble boron concentration. The three experiments with close to 5000 ppm Boron seem to greatly influence the trend determined by the applicant, artificially reducing the correlation slope. Staff also notes that the cask evaluations for PWR contents lie within this area of no benchmark data. Thus, the applicant should justify the validity of the calculated correlation for this parameter as well as its applicability to the PWR contents evaluations given the lack of data in the range of 1500 to about 5000 ppm Boron. If available, applicable data in this range of soluble Boron concentrations should be included in the USL correlation analysis for this parameter. The applicant may also consider applying an additional penalty to the USL trend calculated for this parameter. This penalty could be derived from a statistical analysis that calculates tolerance bands/intervals and subtracting the maximum difference between the parameter trend shown in SAR Figure 6.7.7-6 and the lower tolerance band for the trend from the current USL function, thus capturing the

impacts of the lack of data in the trend analysis for the range of the PWR contents analyses. The criticality analysis should be modified, as necessary, to account for any change to the USL used for the analysis. This information is needed to confirm compliance with 10 CFR 72.124(a).

Summary of Technical Discussion

Discussion of the following material was addressed during the teleconference, with the conclusion that NAC would provide technical clarification with the response summary.

Details and clarification of the material presented are provided as follows.

NAC evaluated soluble boron concentrations with various data sets as part of the criticality validation. This effort was undertaken to assure that a single correlation (or minimum USL) may be applied to PWR systems containing soluble boron and BWR systems and transport calculations that do not contain boron. MAGNASTOR validation calculations in the SAR represent data in the soluble boron correlation ranging from 0 ppm to approximately 5000 ppm to cover the range of expected soluble boron needs and to avoid the need for extrapolating data. All 183 data points are applicable within this constraint. The base data for the validation effort is obtained from peer reviewed and internationally (and United States) accepted critical experiment summaries published as the "International Handbook of Evaluated Criticality Safety Benchmark Experiments, NEA/NSC/DOC(95)03, September 1998." Newer revisions of the handbook were reviewed to assure no errors were made in the data or models employed. As the higher soluble boron data points represent valid experimental results from LEU-COMP-THERM-50, which contained 800 and 5000 ppm data, and the results were not statistical outliers, there is no technical reason for discarding the data or not employing the data. As clearly indicated by the correlation coefficient being significantly less than 1 (<0.2 for the 183 data point set), there is no (or, at most, a weak) correlation/trend of k_{eff} versus soluble boron in the range studied. Therefore, adding or removing data points from the plot, including those at a higher soluble boron level, may change the slope of the data set but not the conclusions drawn.

The results of the statistical analysis of the trend line for various data sets and the resultant USL correlation are shown in the following Table 6-5. Included in the table are reduced data sets to address concerns raised in draft RAI 6-4, which are discussed further. As shown in the table, removing the three high soluble boron points (going from 183 to 180 data points) increases the minimum USL slightly (by only 0.0003 Δk) and, therefore, does not "greatly influence the trend" and does not "artificially reduce the correlation slope" to any resolvable degree (minimum USL from these calculations are greater than the USL of 0.9372 employed in the analysis).

Note that Table 6-5 also includes a set of 186 data points that includes a 2500 ppm data point that was removed at the NRC's request as a response to a previous RAI. As the

slope of all correlations is positive (note that based on the correlation coefficient, NAC does not consider this to be an indication of analysis trend), any postulated increase in soluble boron would result in a smaller bias. Applying a minimum USL of 0.9372 (below the 0 ppm USL for the data sets evaluated in the soluble boron study) to assemblies in the 1500 ppm to 2500 ppm range in question, therefore, represents a conservative bias application. Open literature contains no information that would lead to the assumption of an increased code bias in the interpolated region of the soluble boron curve. No further processing or adjustments are required to the MAGNASTOR USL as a result of the use of the 5000 ppm data points and the interpolation in the data to 1500 to 2500 ppm.

Table 6-5 USL Calculations for Soluble Boron

# Points	R^2	R	Low		AOA Range		High	USL Limit				USL Low	USL High
186	0.0299	0.173	0	<=	X	<=	4986	0.9377	+	5.62E-07	X	0.9377	0.9405
183	0.0173	0.132	0	<=	X	<=	4986	0.9379	+	3.96E-07	X	0.9379	0.9398
180	0.1036	0.322	0	<=	X	<=	1511	0.9382	+	1.84E-06	X	0.9382	0.9409
55	0.0482	0.220	0	<=	X	<=	4986	0.9360	+	7.03E-07	X	0.9360	0.9395
51	0.3528	0.594	0	<=	X	<=	1511	0.9351	+	4.58E-06	X	0.9351	0.9420

In draft RAI 6-4, the question is raised whether 0 ppm experimental data should be included in the soluble boron calculation. As the system will operate in 0 ppm for transport (PWR and BWR) and 0 ppm in storage (BWR), an engineering judgment was made that all 183 data points represent valid information to be used in the correlation. To understand the relative effect on the USL of this decision, the bias calculation included correlations for 55 and 51 data points in addition to the 180 data points discussed previously.

- A 180 point data set removes the high soluble boron data points. The result is a slightly flatter data fit with a slight (0.0003 Δk) increase in the minimum USL for the soluble boron correlation.
- A 55-point fit removes the experiment sets where no soluble boron is present, while retaining 0 ppm cases for the experiment sets where subcases contain soluble boron (included are the four data points above 1500 ppm—three at 5000 and the one 2500 ppm data point from LEU-THERM-COMP-014). The result of this evaluation is similar to those obtained from the higher number of data point sets with a USL reduction of approximately 0.002 Δk at the low end (0 ppm) of the correlation. Applying the reduced data set to a low ppm configuration (in particular, a 0 ppm model) without simultaneously considering the full range of 0 ppm experiments is inconsistent with the goal of obtaining a high confidence USL. Furthermore, the low correlation coefficient clearly indicates that the linear correlation is weak and that employing the USL at the

correlation end-points is subject to significant change by adding data points to the evaluated set (as demonstrated by the analysis of the 180/183/186 data sets). The low end USL from the reduced data set is, therefore, not applicable in establishing limits for the overall code performance. At a minimum of 1500 ppm (PWR SAR lower soluble boron limit), the correlation results in a USL of 0.9371, which does not affect any of the calculated enrichment limits.

- A 51-point data set similar to the 180-point set removes the higher soluble boron cases from the 55-point data set. Results for this set are similar to the 55-point data set with a predicted USL at 0 ppm, not representative of the majority of the experimental data. The 1500 ppm minimum PWR soluble boron USL based on the 51-point correlation is 0.9420 (significantly higher than the USL of 0.9372 used in the MAGNASTOR analysis). For application in the 0 ppm BWR analysis, the 0 ppm data points are certainly applicable, increasing the calculated USL to the results of the 183 (or 180) data point sets.
- Considering only the 0 ppm data yields a code bias of $\Delta k = 0.0054$, with a standard deviation of 0.0017. Establishing an upper limit by simply taking 0.95 bias-2 bias uncertainty yields an equivalent upper subcritical limit of 0.9412, a value higher than the 0.9372 in the MAGNASTOR analysis.

Proposed Resolution
Category 3

No further information is required in the SAR.

Draft SAR Text Change

SAR text revision is not required.

Chapter 8.0 Materials Evaluation

Section 8.11 Cladding Integrity

8-1 Draft RAI

Clarify what bases were used to show that thermal cladding temperature radial gradients are less than 1°F during the reflooding of the canister.

Chapter 4 of the SAR presents the thermal evaluation based on a homogenized basket region characterized by effective thermal properties. This modeling approach would not be adequate to obtain any detailed temperature distribution at the cladding or fuel level. This information is needed to assure compliance with 10 CFR 72.11 and 72.236.

Summary of Technical Discussion

NAC provided a discussion on how the fuel rod cladding 1°F thermal gradient was developed from the RELAP thermal hydraulic analysis performed for the TSC reflood operation. The text in question states "Thermal hydraulic analyses results show thermal cladding temperature radial gradients are less than 1°F during the reflooding of the canister." Although the current SAR text identifies the basis for the reported thermal gradient as the thermal hydraulic analysis the staff discussion identified the objective for clarification to be added to the SAR that identifies the bases to highlight that the source of this result was independent of the thermal heat transfer models and analyses presented in Chapter 4.

Proposed Resolution
Category 2

NAC agrees to provide an edit to SAR Section 8.11 providing the requested clarification.

Draft SAR text change

Proposed text: Section 8.11, page 8.11-3
"..... Addition of water at 8 gpm permits the water to rise in the canister at a maximum rate of 0.8 inch per minute. ***The RELAP*** thermal hydraulic analyses ***used to evaluate the TSC reflood operation*** show thermal cladding temperature radial gradients are less than 1°F during the reflooding of the canister. Such a small increase is consistent with the gradual cooling ......"

Chapter 9.0 Operating Procedures

9-1 Draft RAI

Remove the discussion in the operating procedures that indicates procedures can be developed for dry loading and unloading.

The text at the bottom of SAR page 9-1 indicates that the operations guidance currently provided in the SAR can be appropriately applied to the development of dry loading and unloading of the cask system. However, the detailed procedures and associated analyses are not provided in the SAR. In addition, there are potential issues associated with dry loading and unloading which staff would likely identify in accordance with Interim Staff Guidance No. 22 (ISG-22) "Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel." This information is needed to confirm compliance with 10 CFR 72.122(h)(1).

Summary of Technical Discussion

NAC acknowledged staff comment.

Proposed resolution
Category 2

NAC agrees to remove the text addressing development of procedures for dry loading and unloading.

Draft SAR text change

Proposed text: Section 9, page 9-1
"......Therefore, the TSC external surfaces are expected to be essentially free of removable contamination during long-term storage operations.

Tables in Chapter 3 provide the handling weights ...."

Section 9.1.1 Loading and Closing the TSC

9-2 Draft RAI

Perform a vacuum drying analysis in Chapter 4 of the SAR to determine vacuum drying times when not using annulus circulating water cooling system. Otherwise, remove the statement on page 9.1-4 of the SAR that states: "Vacuum drying times when not using the annulus circulating water cooling system shall be determined and evaluated on a site-specific basis in accordance with 10 CFR 72.48."

If not using annulus cooling during vacuum drying is optional, the applicant should provide in the SAR supporting analysis to justify this (e.g., limiting the maximum decay heat, etc.). The vacuum drying times for these conditions should be added to the proposed Technical Specifications. Reference to 10 CFR 72.48 change authority generally should not be considered an operating procedure. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC acknowledged staff comment.

Proposed Resolution
Category 2

NAC agrees to remove the text addressing the use of the 10 CFR 72.48 change process to make a change in vacuum drying times for a system configuration not using the circulating water cooling system.

Draft SAR text change

Proposed text: Section 9.1, page 9.1-4
"28 ..... Note: Annulus circulating water cooling system operation allows the vacuum drying and TSC transfer times in Table 9.1-3 and Table 9.1-4 to be utilized.

29. Initiate clean water....."

9-3 Draft RAI

Modify stage 29 of the sequence of operations to load and close the TSC, to specify that the outlet temperature of the annulus cooling water discharging through the upper fill lines is to be monitored and the user should make sure the monitored outlet temperature be equal or less than 113°F.

The thermal analysis assumes this value for the TSC shell. This temperature should be monitored to correspond to this value to account for uncertainties in the analysis due to modeling assumptions and numerical errors. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC acknowledged staff comment.

Proposed Resolution
Category 2

NAC agrees to incorporate the requirement to monitor the TSC and TFR water annulus outlet temperature.

Draft SAR Text Change

Proposed text: Section 9.1, page 9.1-4
"29. Initiate clean water flow into the transfer cask lower fill lines with annulus water discharging through the upper fill lines. ***Ensure water flow is maintained to keep the outlet*** water temperature **≤** ***113°F."***

Section 9.1.3 Transporting and Placing the Loaded Concrete Cask

9-4 Draft RAI

Clarify the description of Air Pad Rig Set provided on Table 9.1-1 of the SAR. Currently the SAR states the following description: “A device...air supplied at a high volume”. The description should be modified as follows: ”A device...air supplied at a high pressure.” This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC identified that the description of the Air Pad Rig Set is representative of a high volume system and not a high pressure system. Rig Set Technical Data Chart information provided by the equipment supplier identifies the hardware using physical air pressure and air flow rates representative of a high volume system.

Proposed Resolution
Category 1

NAC agreed to provide supplemental air bearing equipment information. Technical data chart information defines system air pressure as 64 psi and air consumption at 435 scfm. Information on the air bearing equipment is provided on the following figure as copied from the referenced website.

Draft SAR Text Change

SAR text change is not applicable.

Supplemental Information for Draft RAI 9-4.

Reference web site:
"http.//www.solvinginc.com/rig_set_modular_air_bearing_syst.htm"
Sheet 1 of 2

AMERICAN
SOLVING
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PRODUCTS:
AIR CASTERS
How they work!
AIR CASTERS FOR RIGGING
AIR PALLETS (MANUAL)
POWER-DRIVEN TRANSPORTERS
INDUSTRIAL TURN TABLES
MOBILE LIFT TABLES
PAPER ROLL HANDLERS
AUTOMATED GUIDED VEHICLES
APPLICATIONS
ERGONOMIC EQUIPMENT
AEROSPACE TRANSPORTERS
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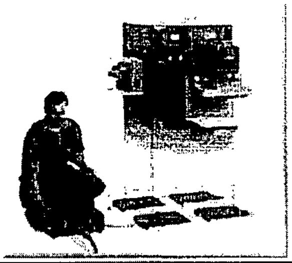

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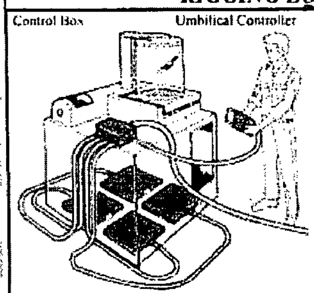

Standard Rig Set Consists of:

- (4) Air Bearing Elements
- (4) Load Modules
- (4) Interconnecting Lines
- (1) Control Box

Optional Items:

- Hand pendant Controller (umbilical attached)
- Supply Hose
- Six Module System
- Alternative Hose Lengths
- Air Jacks

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RIG SET TECHNICAL DATA CHART

Consists of (4) Modules:								
RIG SET MODEL #	RATED CAPACITY (Lbs.)	Connecting HOSE (I.D. In.)	SUPPLY HOSE (I.D.)	1) AIR Pressure (psi)	2) AIR Consumption (scfm)	MODULE Dimensions (in.)	Effective Lift (in.)	3) Overall Deflated (Ht. in)
MLS-8L	2,000	1/2	3/4	13	25	8	3/8	1-3/8 / 2
MLS-12L	4,800	1/2	3/4	14	60	12	3/4	1-3/8 / 2
MLS-8S	4,000	1/2	3/4	26	60	8	3/8	1-3/8 / 2
MLS-12S	10,000	1/2	3/4	28	75	12	3/4	1-3/8 / 2
MLS-15S	16,000	1/2	1	29	90	15	7/8	1-3/8 / 2
MLS-21S	34,000	3/4	1-1/4	32	125	21	1	2
MLS-27S	56,000	3/4	1-1/4	32	145	27	1-1/4	2-7/16
MLS-36S	100,000	3/4	1-1/2	32	200	36	2	2-11/16

Supplemental Information for Draft RAI 9-4 (cont'd)

Reference web site:
"http.//www.solvinginc.com/rig_set_modular_air_bearing_syst.htm"
Sheet 2 of 2

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MLS-48S	180,000	3/4	1-1/2	32	240	48	3	2-11/16
MLS-60S	280,000	3/4	1-1/2	32	330	60	3	3
MLS-8H	8,000	1/2	1	51	100	8	3/8	1-3/8 / 2
MLS-12H	20,000	1/2	1	57	100	12	3/4	1-3/8 / 2
MLS-15H	32,000	1/2	1	58	160	15	7/8	1-3/8 / 2
MLS-21H	68,000	3/4	1-1/4	63	220	21	1	2-3/16
MLS-27H	112,000	3/4	1-1/2	65	250	27	1-1/4	2-7/16
MLS-36H	200,000	1	2	63	355	36	2	2-11/16
MLS-42H	272,000	1	2	63	395	42	3	2-11/16
MLS-48H	360,000	1	2	64	435	48	3	2-11/16
MLS-60H	560,000	1	2	64	585	60	3	3

1. At full rated capacity.
2. These values are for smooth sealed concrete w/ good light reflective quality, some surface deterioration, floor cracks max of 1/16" wide & filled expansion joints. (Maximum Air consumption dependent on floor conditions).
3. Models MLS 8, 12 and 15 are shown with both cast aluminum top plates and also extruded aluminum top plates.

12-1 Draft RAI

Verify that the thermal results presented in Chapter 12 (Accident Analyses) of the SAR are consistent with the results reported in Chapter 4 (Thermal Evaluation) of the SAR.

The thermal results presented in Chapter 12 of the SAR are not consistent to the results reported in Chapter 4 of the SAR for off-normal and accident events. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC acknowledged the staff comment and noted that the identified differences in reported temperature have been corrected by supplement to the application.

Proposed Resolution
Category 1

NAC provided a supplement to the application with corrected SAR changed pages on January 24, 2008. Additional SAR revision is not required.

Draft SAR Text Change

SAR text change has been documented with the above-referenced supplement.

Chapter 13.0 Operating Control and Limits

13-1 Draft RAI

Modify proposed LCO 3.1.1 to specify the time limits for vacuum drying, backfilling, and TSC transfer.

These time limits are specified in Chapter 9 of the SAR but they also need to be included in the proposed Technical Specifications (see RAI 9-1). The SAR currently analyzes appropriate time limits for the specific MAGNASTOR design and associated operations requested for certificate approval. Although the proposed TS suggests that the user may define unique vacuum drying times, the proposed TS (and SAR) does not clearly specify a methodology that could be independently applied by any general licensee for various site and cask configurations and loading procedures. The staff has not reviewed and approved a methodology for use by a general licensee. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC acknowledged staff comment and provided discussion of the objective to incorporate user flexibility highlighting that the system thermal performance limits have been incorporated into Technical Specification Section 5.2 subparagraph c. This section of the Technical Specification states that the maximum fuel cladding temperature is limited to 400°C, and that cooling cycles greater than 65°C are limited to 10 or less for fuel having burnup greater than 45 GWd/MTU. Procedures for controlling system performance are provided in Section 9.1, step 59, where the presented heat load dependent system drying times are taken from thermal analyses presented in Chapter 4. NAC identified that the SAR technical content included the analytical models and methodology used to perform the thermal transient analysis for the system drying operation, Section 4.4.1, and that the structure of the application was in accordance with the guidance provided by NUREG-1745.

As noted in the above RAI text, the staff identified that the details presented in the SAR may not be adequate for a general licensee to independently perform these analyses, and that based on this limitation much more detail would need to be presented in the SAR and reviewed by the staff, or drying time limits as currently defined in Chapter 9 operating procedures would need to be defined in the Technical Specifications.

NAC has offered options to the system drying times being in the Technical Specifications without reaching agreement on an acceptable alternative. Based on the current status of this issue and NRC staff direction that the most expedient path to closure is to include the drying times in the Technical Specifications, NAC has provided proposed SAR text for LCO 3.1.1. Definition of specific operational times will be added Appendix A, Section 1.1 Definitions.

Proposed Resolution
Category 2

If requested by NRC management, NAC will incorporate the heat load-dependent vacuum drying times for both PWR and BWR loading configurations, as calculated and presented in Chapter 4 and defined in Chapter 9 Operating Procedures, Tables 9.1-3 and 9.1-4 into LCO 3.1.1, Technical Specification.

Draft SAR Text Change

LCO 3.1.1 the following vacuum drying times shall be met as appropriate:

1) The time duration from the beginning of canister draining through completion of vacuum dryness test and backfill with helium shall not exceed the following:

PWR Drying with 8 hours TSC Transfer

Heat Load (kW)	VACUUM TIME LIMIT (hours)	HELIUM BACKFILL (hours)	TSC TRANSFER TIME (hours)
≤20	No Limit	0	8
25	50	0	8
30	19	7	8
35.5	15	7	8

PWR Drying with Maximum TSC Transfer

Heat Load (kW)	VACUUM TIME LIMIT (hours)	HELIUM BACKFILL (hours)	TSC TRANSFER TIME (hours)
≤25	No Limit	24	48
30	32	24	22
35.5	24	24	22

BWR Drying with 8 hours TSC Transfer

Heat Load (kW)	VACUUM TIME LIMIT (hours)	HELIUM BACKFILL (hours)	TSC TRANSFER TIME (hours)
≤15	No Limit	0	8
20	No Limit	0	8
25	No Limit	0	8
29	34	6	8
30	31	6	8
33	26	6	8

BWR Drying with Maximum TSC Transfer

Heat Load (kW)	VACUUM TIME LIMIT (hours)	HELIUM BACKFILL (hours)	TSC TRANSFER TIME (hours)
≤25	No Limit	24	65
29	No Limit	24	32
30	44	24	32
33	33	24	32

2) The time duration from the end of 24 hour in-pool cooling or by the annulus circulating water cooling system through completion of vacuum dryness test and backfill with helium shall not exceed the following:

	Heat Load (kW)	Time Limit (hours)
PWR	35.5	11
BWR	33	16

13-2 Draft RAI

Modify Table 2-1, PWR Fuel Assembly Limits, on page 13B-2 of the SAR to specify that the Decay Heat Per Fuel Assembly is 959 W. Otherwise, clarify in this Table that 1200 W is the maximum value for a regionalized region as described on Table 2-7 and Figure 2-1.

This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

Summary of Technical Discussion

NAC identified that the maximum system assembly heat load was correctly identified in the tabulated presentation and that item F in this same tabulated summary specifically addressed the uniform load configuration. Staff acknowledged that the information was currently presented in the table, however, were of the opinion that additional clarification could be achieved with a notation that the noted 1,200 watt heat load was representative of the preferential loading configuration.

Proposed Resolution
Category 2

NAC agrees to revise Table 2-1, PWR Fuel Assembly Limits, to clarify that the stated maximum assembly decay heat of 1200 W is applicable to the preferential fuel load configuration.

Draft SAR Text Change

Proposed text: page 13B-2
"c. Decay Heat Per Assembly (***Preferential Loading***)" ≤1,200 watts

13-3 Draft RAI

Modify the proposed Technical Specifications in the following locations:

Add the word "solid" before the words "dummy rod" in item 2 of the Damaged Fuel definition.

Add "(BWR)" after "Number of Partial Length Fuel Rods" in Appendix B, Section 2.1.1. This contents specification applies only to BWR contents.

Remove the maximum channel thickness from the first bullet of Table 2-9 in Appendix B. This maximum thickness is specified in Table 1-A-2 of the FSAR, as per Section 2.1.2 of Appendix A of the Technical Specifications. Specifying the thickness in Appendix B as well precludes the ability to change this parameter by the process specified in Section 2.1.2 of Appendix A of the Technical Specifications.

Change the references to Table 2-2 to Table 2-3 in paragraph I.C of Table 2-1 and the reference to Table 2-9 to Table 2-10 in paragraph I.E of Table 2-8. Tables 2-3 and 2-10 seem to be the more appropriate tables for the discussions in the noted paragraphs of Tables 2-1 and 2-8.

This information is needed to confirm compliance with 10 CFR 72.236(a).

Summary of Technical Discussion

NAC acknowledged staff comment.

Proposed Resolution
Category 2

NAC agrees to incorporate the staff requested edits.

Draft SAR Text Change

Revise the damaged fuel definition on page 13A-2 item 2 as follows:

2. Individual fuel rods are missing from the assembly and the missing rods are not replaced by ***solid*** dummy rod that displaces a volume equal to, or greater than, the original fuel rod.

"(BWR)" is added to the partial length rods statement on Page 13A-15 Section 2.1.1. For consistency "PWR" is added to the non-fuel hardware statement in the same list as it only applies to PWR contents.

The fuel parameters listed in Appendix B of these Technical Specifications include the following:

Fissile Isotope
Fuel Class (e.g. 14×14, 15×15)
- Number of Fuel Rods
- Number of Guide Tubes (PWR)
Maximum Uranium Mass
Maximum Initial (Planar Average) Enrichment
Maximum Assembly Average Burnup
Minimum Cooling Time
Minimum Active Fuel Average Enrichment
Cladding Material
PWR Nonfuel Hardware—e.g., BPRA/TPAs (cooling time and burnup)
Maximum Weight per Storage Location
Maximum Decay Heat per Storage Location
Fuel Condition
Number of Partial Length Fuel Rods ***(BWR)***

The maximum channel thickness is removed from the first bullet of Table 2-9 in Appendix B.

- Each BWR fuel assembly may include a zirconium-based alloy channel ~~***up to a nominal channel thickness of 120 mil.***~~

Section I.C of Table 2-1 and TI.E of Table 2-8 are revised to refer to Table 2.3 and Table 2-10 respectively. The first reference to Table 2-2 is retained in I.C of Table 2-1 as it limits the allowable weight of the assembly including non-fuel hardware.

Table 2-1

C. PWR UNDAMAGED FUEL ASSEMBLIES may contain a flow mixer (thimble plug), a burnable poison rod assembly, or a control element assembly consistent with Table 2-2. Assembly lattices not containing the nominal number of fuel rods specified in ***Table 2-3*** must contain solid filler rods that displace a volume equal to, or greater than, that of the fuel rod that the filler rod replaces. Assemblies may have stainless steel rods inserted to displace guide tube "dashpot" water. Loading activated nonfuel hardware requires extended fuel assembly cool times, and Table 2-4 presents the additional fuel assembly cool times required. Minimum BPRA and thimble plug cool times as a function of burnup (exposure) are shown in Tables 2-5 and 2-6. Alternatively, the ^{60}Co curie limits in Tables 2-5 and 2-6 may be used to establish site-specific nonfuel hardware constraints.

Table 2-8

E. Assembly lattices not containing the assembly type-specific nominal number of fuel rods (see ***Table 2-10***) must contain solid filler rods that displace a volume equal to, or greater than, that of the fuel rod that the filler rod replaces.

13-4 Draft RAI

Change footnote a of Table 2-10 in Appendix B of the proposed Technical Specifications to read: Location of the partial length rods is illustrated in Figure 6.2.1-1 of the FSAR (Rev. 1, July 2007).

The current footnote reference does not match the actual figure depicting the locations of the partial-length rods for the applicable assemblies. Furthermore, the reference needs to indicate the appropriate revision of the drawing upon which the criticality analysis and the allowable contents specifications are based. This is necessary because any changes to the applicable assemblies with respect to the positioning of the partial-length rods constitute a change in the allowable contents specifications. This information is needed to confirm compliance with 72.236(a).

Summary of Technical Discussion

The specific revision of the figure was not included in the Technical Specification to allow 10 CFR 72.48 evaluations on modified partial rod locations. The presence of partial length rods has a minor effect on system reactivity but the specific location of the rods will not result in changes to the allowed enrichment. As NAC has not presented calculations for the possible variations GE may manufacture, NAC proposes to copy the figure into Section 1-A as Figure 1-A-1. This will allow for prior NRC approval per Section 2.1.2 of Appendix A.

Proposed resolution
Category 2

NAC has made the requested edits to the SAR, per the proposed changes below.

Draft SAR Text Change

Revise Section 2.1.2 on page 13A-15 to include partial length rods.

The fuel parameters listed in Appendix 1-A of the FSAR include the following:
Maximum Pitch
Minimum Cladding Outer Diameter
Minimum Cladding Thickness
Maximum Pellet Outer Diameter
Maximum Active Fuel Length
Subchannels (BWR)
Maximum Channel Thickness (BWR)
Location of Partial Length Rods (BWR)

To change these parameters requires prior NRC approval. The process for requesting approval is described in Section 2.2.

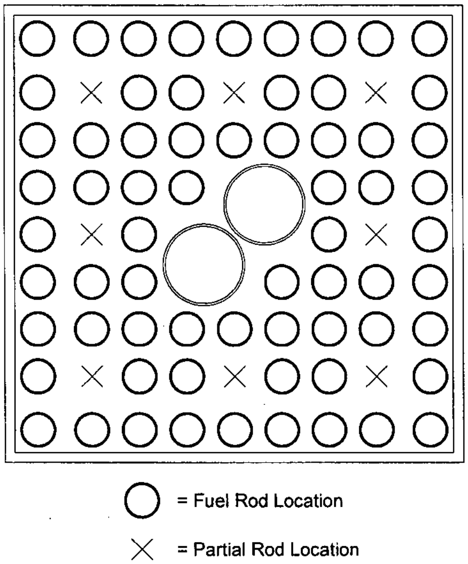
Footnote "a"on Table 2-10 in Appendix B of the proposed Technical Specifications to read:

"Location of the partial length rods is illustrated in ***Figure 1-A-1*** of the FSAR."

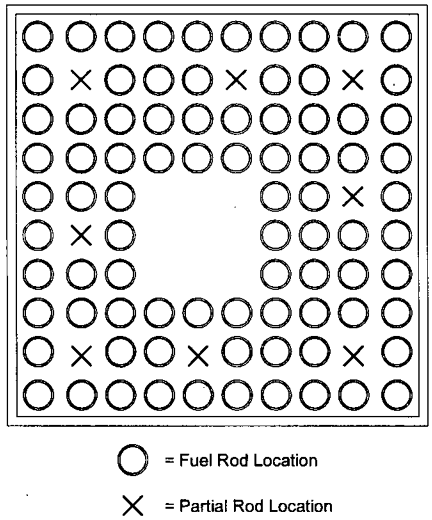
Appendix 1-A is modified as follows:

Table 1-A-2 covers the types of assemblies and their characteristics for the BWR 87-assembly and 82-assembly fuel baskets. ***Figure 1-A-1 locates the partial length rods within the BWR lattice.***

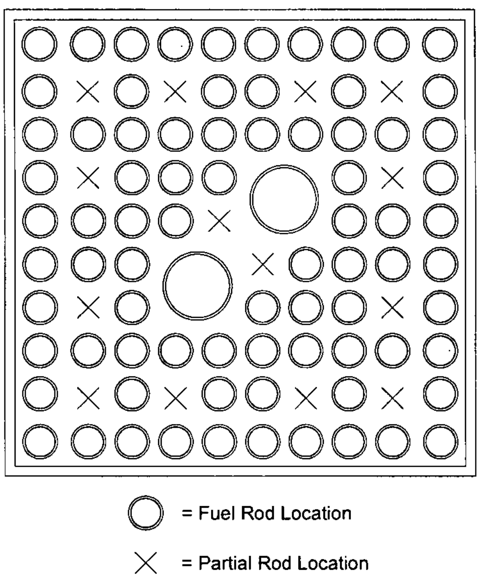
Figure 1-A-1 BWR Partial Length Fuel Rod Location Sketches



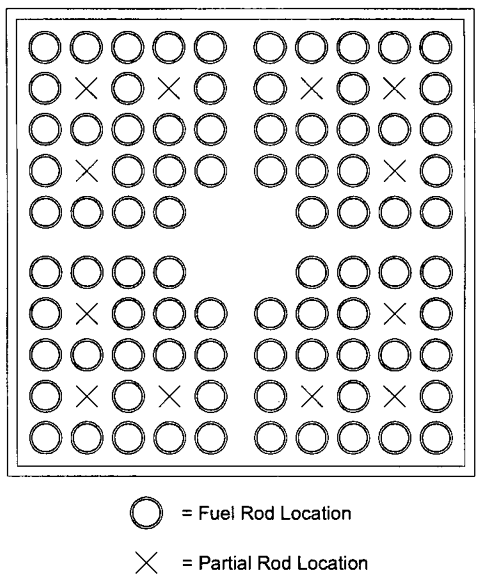
B9_74A 8 Partial Length Rods



B10_91A 8 Partial Length Rods



B10_92A 14 Partial Length Rods



B10_96A 12 Partial Length Rods

Certificate of Compliance

C-1 Draft RAI

Add a proposed certificate condition for cask users to verify mass flow rates with the CFD predictions described in the SAR for first-use of cask systems at higher heat loads. Discuss in the SAR, acceptable methods that can be used to experimentally verify the mass flow rates of the MAGANASTOR storage system inlet and outlet vents during operation.

Due to the requested heat load and operating conditions (pressurized canister, high burnup fuel, etc.), additional assurance of the validity of the predicted mass flow rates is necessary, based on new information obtained by staff for high heat load cask configurations. The peak cladding temperature is highly sensitive to the predicted mass flow rate value. However, there is inherent uncertainty in CFD-calculated mass flow rates, given the limited experimental data to validate ventilated cask configurations. Based on sensitivity studies, the staff determined that a 10% uncertainty in CFD-calculated mass flow rates, for example, could result in significant increases in peak cladding temperatures at high heat loads for certain design configurations. This information is needed to assure compliance with 10 CFR 72.11, 72.24(d), and 72.236(f).

Summary of Technical Discussion

NAC acknowledged staff comment and identified that consideration will be made for the calculated maximum system component temperatures resulting from design bases heat loads and identified temperature margins relative to the maximum component temperature limits. Based on this data a requirement for "First System Use" will be added to the proposed Technical Specifications validating system performance for the higher system heat loads.

Proposed resolution
Category 2

NAC agrees to incorporate the requirement to verify mass flow rates as the staff has requested. Steady state thermal analyses has shown that the maximum fuel cladding temperature changes approximately 15°F for each kilowatt loaded. Based on this calculated system performance and the design margin of 38°F for the design basis heat load of 35.5 kW it can be projected that a temperature margin in excess of 100°F will exist for a heat load of 30 kW. It is noted that the difference in temperature between the inlet air and outlet air is related to mass flow and that anticipated system instrumentation available at the site is more suited for temperature measurements. Therefore, NAC proposes that temperature measurements are performed to validate system thermal performance as an alternative to the requested mass flow measurement.

Based on these evaluations and considerations NAC proposed to perform a temperature measurement test for the first system placed in service with a heat load equal to or greater than 30 kW.

Draft CoC Text Change

Proposed text: Section 13A, page 13A-32

5.6 Special Requirements for the First System Placed in Service.

The heat transfer characteristics and performance of the MAGNASTOR SYSTEM will be recorded by air inlet and outlet temperature measurements of the first system placed in service with a heat load equal to or greater than 30 kW. A letter report summarizing the results of the measurements will be submitted to the NRC in accordance with 10 CFR 72.4 within 60 days of placing the loaded cask on the ISFSI pad. The report will include a comparison of the calculated temperatures of the MAGNASTOR SYSTEM heat load to the measured temperatures. A report is not required to be submitted for the MAGNASTOR SYSTEMs that are subsequently loaded, provided that the performance of the first system placed in service with a heat load of ≥30 kW is demonstrated by the comparison of the calculated and measured temperatures.