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Log # TXX-09001

Ref. # 10 CFR 50.90

January 22, 2009

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION
DOCKET NOS. 50-445 AND 50-446
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING SPENT FUEL POOL CRITICALITY LICENSE AMENDMENT REQUEST
(TAC NOS. MD8417 AND MD8418)

REFERENCES:
1. Letter logged TXX-07106 dated August 28, 2007 from Mike Blevins of Luminant Power to the NRC submitting License Amendment Request (LAR) 07-004.
2. Letter logged TXX-08087, dated June 30, 2008, from Mike Blevins of Luminant Power to the NRC submitting a supplement to the Spent Fuel Pool Criticality Analysis.
3. Letter dated November 19, 2008, from Balwant Singal of NRR to Mr. Blevins.
4. Letter logged TXX-08148, dated December 10, 2008, from Mike Blevins of Luminant Power to the NRC submitting responses to request for additional information regarding Spent Fuel Pool Criticality License Amendment Request.

Dear Sir or Madam:

Per Reference 1, Luminant Generation Company LLC (Luminant Power) requested changes to the Comanche Peak Steam Electric Station, herein referred to as Comanche Peak Nuclear Power Plant (CPNPP), Units 1 and 2 Operating Licenses and to Technical Specification 1.0, "USE AND APPLICATION" to revise rated thermal power from 3458 MWT to 3612 MWT. As part of the request to increase rated thermal power, Luminant Power requested to revise Technical Specifications 3.7.17, "Spent Fuel Assembly Storage," for the spent fuel pool criticality analysis CPNPP Units 1 and 2. In Reference 2, Luminant Power supplemented the information supporting the spent fuel pool criticality analysis.

On November 19, 2008, the NRC provided Luminant Power with a request for additional information (Reference 3) regarding the proposed changes to rated thermal power. The responses to these questions were provided in Referenced 4. Per telephone conversation with the NRC on January 13, 2009, the NRC confirmed that Luminant Power's response to the four of the remaining 5 questions could be provided by January 23, 2009 with the final question (26) and supporting revised Technical Specifications pages on February 16, 2009.

A001
NRR

Attachment 1 contains information proprietary to Westinghouse Electric Company LLC, and is supported by an affidavit signed by Westinghouse, the owner of the information. Attachment 2 is the non-proprietary version of Attachment 1. The enclosed affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b) (4) of Section 2.390 of the Commissions' regulations. Accordingly, it is respectfully requested that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of Attachment 1 or the supporting Westinghouse affidavit should reference CAW-09-2521 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

The proprietary information transmitted in this letter includes bracketed text in the following:

- Response to Question 12, pages 9 and 10
- Response to Question 17, pages 14, 15, and 16

Proprietary information is indicated in [brackets], followed by a superscript code. The codes are defined as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

In accordance with 10CFR50.91(b), Luminant Power is providing the State of Texas with a copy of this proposed amendment supplement.

This communication contains no new or revised commitments. Should you have any questions, please contact Mr. J. D. Seawright at (254) 897-0140.

I state under the penalty of perjury that the foregoing is true and correct.

Executed on January 22, 2009.

Sincerely,

Luminant Generation Company LLC

Mike Blevins

By: Fred W Madden
Fred W. Madden
Director, Oversight & Regulatory Affairs

Attachments:
1. Response to NRC Request for Additional Information (Proprietary)
2. Response to NRC Request for Additional Information (Non-Proprietary)

Enclosure: Westinghouse authorization letter CAW-09-2521 with accompanying affidavit, Proprietary Information Notice and Copyright Notice.

c - E. E. Collins, Region IV
B. K. Singal, NRR
Resident Inspectors, CPNPP

Ms. Alice Rogers
Environmental & Consumer Safety Section
Texas Department of State Health Services
1100 West 49th Street
Austin, Texas 78756-3189

ATTACHMENT 2 TO TXX-09001

Response to NRC Request for Additional Information
(Non-Proprietary)

Question 10

The axial burnup profile used in WCAP-16827-P is indicated by NUREG/CR-6801 to be non-conservative for burnups below 46 GWD/MTU, while WCAP-16827-P used this profile exclusively for any case involving a distributed axial burnup profile. Therefore every case involving a distributed axial burnup profile at a burnup below 46 GWD/MTU is potentially non-conservative. NUREG/CR-6801 is generic, considering the axial burnup profiles for several fuel design types, therefore opening the potential for a more specific analysis to show acceptable results. The licensee and its vendor attempted to do that in WCAP-16827, Addendum 1. However the staff finds that analysis insufficient for the following reasons:

a) **WCAP-16827, Addendum 1 states, "The reactivity effects due to axial burnup profile for burnups less than 46 GWd/MTU are only applicable at low enrichments, since higher enrichments require greater than 46 GWd/MTU of burnup for acceptable storage. Therefore, fuel assemblies of 2.4 w/o ^{235}U enrichment are investigated to determine the reactivity effects of a limiting burnup profile." However, not a single 3.0 w/o ^{235}U burnup credited in WCAP-16827-P equals or exceeds 46 GWD/MTU. Most 4.0 w/o ^{235}U burnup levels credited in WCAP-16827-P do not equal or exceed 46 GWD/MTU. Additionally, a large number of the simulations performed to determine the amount of burnup to be credited for the 4.0 w/o ^{235}U and 5.0 w/o ^{235}U enrichment levels were performed at burnups below 46 GWD/MTU.**

b) **WCAP-16827, Addendum 1 states, "To properly justify the conservatism of the axial burnup profile [...]^{a,c} considered in the original (Reference 1) analysis, a thorough analysis of axial burnup profiles from the database of Reference 8 is conducted. The database of Reference 8 contains thousands of axial burnup profiles from several reactors, and reactor types, around the world. Since the lattice design, and the reactor type in which it is irradiated, influences the axial burnup profile of fuel assemblies, only axial burnup profiles from Westinghouse 17x17 fuel assemblies, identical to that utilized at CPSES, Units 1 and 2, are considered in this investigation. Furthermore, only the limiting axial burnup profiles from this assembly design are considered. The limiting axial burnup profile is chosen based on the relative burnup of the top two nodes. Fuel assemblies from the database are audited, and the assembly with the minimum relative burnup in the top two nodes is chosen to represent the limiting axial burnup profile for a given burnup range. Mere comparison of the relative burnup in the top two nodes is not how the limiting profile was determined in DOE/RW-0472 or NUREG/CR-6801, therefore the staff is unsure how this method adequately determines the limiting profile from the limited Westinghouse 17x17 population of profiles used at each burnup increment. NUREG/CR-6801 Appendix A, Axial Discretization and Boundary Conditions, clearly indicates that more than the top two nodes are important for determining the 'end effect.' Additionally, NUREG/CR-6801 states, "...that often a very small secondary peak is observed at the other end of the fuel rod, due to the reduced burnup at that end as well." To put 'very small' in context, NUREG/CR-6801 considers 0.005 Δk_{eff} to be small. Since WCAP-16827-P reserves an analytical margin of 0.005 Δk_{eff}, in this context a 'very small' impact is worth determining.**

Therefore the staff finds this method for determining the limiting profile to be insufficient.

c) **WCAP-16827, Addendum 1 states, "The limiting fuel representations described above are simulated at 2.4 w/o ^{235}U in the "4-out-of-4" storage configuration model from Reference 1. As storage configurations with fewer assemblies or reactivity-suppressing materials will exhibit a dampening effect on any reactivity differences due to axial burnup profiles, this storage configuration is chosen to bound reactivity effects for all configurations." While the "4-out-of-4" storage configuration may be bounding with respect to the other storage configurations; that does not mean the result for those storage configurations will be zero. It appears that WCAP-16827, Addendum 1 made no effort to determine the effect on those storage configurations.**

d) **In the simulations of 2.4 w/o ^{235}U in the "4-out-of-4" storage configuration WCAP-16827, Addendum 1 selects 'limiting' Westinghouse 17x17 axial burnup profiles from the database used in the DOE Topical Report and NUREG/CR-6801. However, when only the Westinghouse 17x17 axial burnup profiles are considered the population is significantly reduced. Additionally, there is no evidence to support the idea that these are or were limiting Westinghouse 17x17 axial burnup profiles. Also, there is no CPSES, Units 1 and 2 site-specific justification for using the selected profiles. Therefore the staff believes there is currently insufficient information to conclude that the profiles used in the simulations are limiting.**

e) **The simulations of 2.4 w/o ^{235}U in the "4-out-of-4" storage configuration in WCAP-16827, Addendum 1 are represented in Figure 3-5. Figure 3-5 clearly shows increasing non-conservatism with decreasing burnup. However the simulations only go down to a burnup of 30 GWD/MTU while the 2.0 w/o ^{235}U burnup credited in the "4-out-of-4" storage configuration goes down to 18 GWD/MTU and the simulations used to determine that credit go down to 15 GWD/MTU. This indicates that the WCAP-16827-P, Addendum 1 stated "..maximum reactivity increase observed...," is probably not the maximum reactivity increase.**

f) **WCAP-16827, Addendum 1 espouses applying the reactivity increase from the simulations as an uncertainty to 2.0 w/o ^{235}U total Uncertainty and Bias. However, the staff does not believe the manner in which the axial burnup profile is used warrants it being treated as an uncertainty.**

Therefore the staff requests the licensee determine the effect of using appropriate axial burnup profiles and that the burnup/enrichment loading curves be adjusted accordingly.

Response

The justification of the burnup profile used to represent unblanketed assemblies is presented in this RAI response. A new justification is presented because of the concerns noted above by the staff.

Fuel assemblies with no axial blankets were used at CPNPP only during the first few cycles of operation. These assemblies were used in cycles with significantly lower energy requirements than is typical for more recent cycles. This lower energy requirement resulted in the use of lower average fuel enrichment and reduced discharge burnup for the assemblies compared to recent cycles. The highest enrichment used in an unblanketed assembly was 3.4 w/o ^{235}U. The maximum burnup achieved in an unblanketed assembly was approximately 42,100 MWd/MTU. These values provide the bounds of the burnup and enrichment space that needs to be evaluated for demonstrating that the burnup profile used in the analysis presented in WCAP-16827 is conservative.

A review of end of cycle axial burnup profiles for unblanketed assemblies was performed using a three dimensional core simulator. All the CPNPP burnup profiles were found to be well behaved. Potentially limiting axial burnup profiles were identified based on low burnup in the top three nodes of the fuel assembly. Justification of selecting limiting profiles based on the burnup of the top nodes was provided in the response to Question 11. Two limiting profiles were selected for evaluation. One burnup profile represents assembly average burnup through 30,000 MWd/MTU and the second profile for higher burnups. Both profiles are provided in the table shown below.

Limiting CPNPP Unblanketed Assembly 4-zone Burnup Profiles

Node Midpoint (in)	BU ≤ 30,000 MWd/MTU	BU > 30,000 MWd/MTU
141	0.432	0.473
135	0.698	0.737
129	0.883	0.912
63	1.047	1.042

A series of depletion calculations were performed for fuel assemblies of 3.4 w/o ^{235}U and no axial blankets to compare the reactivity predicted from the actual CPNPP profiles to the WCAP-16827 prediction for burnups ranging from 25,000 to 45,000 MWd/MTU. All depletions were performed using the uprated power and temperature profiles documented in WCAP-16827. The distributed burnup profile used in WCAP-16827 is more limiting than the actual CPNPP profiles for all burnups presented here. The conservatism identified by comparing the axial burnup profile used to the actual burnup profiles is presented in the table below. The uncertainty presented in the table is the root sum square of the uncertainties from each of the KENO calculations.

Conservatism of WCAP-16827 Axial Burnup Profile

Burnup (MWd/MTU)	$\Delta k_{eff} \pm \sigma$
25,000	0.00190 ± 0.00022
30,000	0.00099 ± 0.00026
35,000	0.00716 ± 0.00028
40,000	0.00686 ± 0.00026
45,000	0.00662 ± 0.00027

Several other sources of significant conservatism still exist in these calculations. The largest source is the assumed core operating conditions. The average soluble boron concentration for the early cycles of plant operation was around 500 ppm compared to the 1000 ppm used in these calculations. The outlet temperature was also lower in the pre-uprate conditions. The theoretical density of the fuel also provides conservatism as the as-built density of these early assemblies, including dishing and chamfering, was approximately 93% compared to the 97.5% used in the computational model. It was concluded that the burnup profile used in WCAP-16827 provides reactivity margin when compared to the fuel assemblies present in the Comanche Peak spent fuel pools.

Question 12

WCAP-16827-P uses a uniform burnup profile to model fuel assemblies with axially blanketed fuel. With respect to representing the burnup profile of an assembly with axial blankets, the staff is unaware of any generic analysis that would support definitive conclusions. While NUREG/CR-6801 does state in its conclusion that, "...the axial blankets have significantly lower enrichment than the central region, the end effect for assemblies with axial blankets is typically very small or negative. Furthermore, the lower the initial enrichment of the axial blankets is with respect to the higher enrichment central region, the lower is the end effect." To put 'very small' in context, NUREG/CR-6801 considers 0.005 Δk_{eff} to be small. Since WCAP-16827-P reserves an analytical margin of 0.005 Δk_{eff}, in this context a 'very small' impact is worth determining. WCAP-16827, Addendum 1 provides some information about this item. WCAP-16827, Addendum 1 provides a comparison between a uniform profile and a limiting axial profile selected from profiles of actual blanketed fuel assemblies from recent CPSES, Units 1 and 2 cores. However the staff finds that analysis insufficient for the following reasons:

a) **The criteria for selecting the 'limiting axial profile' was based on the relative burnup in the top two nodes, the same as was described in Question 10b. The staff has the same concerns regarding this method for selecting the limiting axial profile in this instance as discussed in question 10b. Additionally, since the top zone is an axial blanket, the presence of axial blankets would seem to make it less likely that using the top two zones as the criteria would identify the limiting profile.**

b) **WCAP-16827, Addendum 1 states, "...the representation is most conservative at 35 GWd/MTU, reaching a maximum reactivity difference of 1893 ± 41 pcm Δkeff (1 pcm = 10^{-5}). The least conservative time of life is at 60 GWd/MTU when the reactivity difference is 361 ± 39 pcm Δkeff." The comparison is provided in Figure 3-19. Figure 3-19 shows the 'least conservative time of life' to be a negative difference, which is a non-conservative rather than a less conservative resultant. Figure 3-19 also indicates the non-conservatism becomes larger with increasing burnup. Since the "4-out-of-4 with Axial Blankets" storage configuration credits 62,662 MWD/MTU of burnup for 5.0 w/o enriched U^{235} with zero Pu^{241} decay time, this point is non-conservative by an amount that is reasonably expected to exceed the WCAP-16827-P reserved analytical margin of 0.005 Δk_{eff}. Therefore, the "4-out-of-4 with Axial Blankets" storage configuration does not appear to meet the requirements of 10CFR50.68 based on this consideration alone. Additionally, as that point is used to determine a second order polynomial for controlling the burnup/enrichment loading curve for the "4-out-of-4 with Axial Blankets" storage configuration for zero Pu^{241} decay time, that equation is non-conservative by some amount. As other simulations in the "4-out-of-4 with Axial Blankets" storage configuration determinations use burnup levels at or above 60GWD/MTU, those are also non-conservative by some amount.**

c) **While the above discussion utilizes information provided by the licensee, given the way an axially blanketed fuel assembly is modeled in WCAP-16827-P, the manner in which the distributed profile is determined in WCAP-16827-P, Addendum 1, and the lack of information as to whether or not a single distributed profile was used for all burnup levels, the staff is**

uncertain as whether or not the depiction in WCAP-16827, Addendum 1 Figure 3-19 accurately represents the margin (positive or negative), associated with modeling an axially blanketed fuel assembly with a uniform profile.

d) Other than indicating the comparison was made using a uniform and axially distributed profile in the "4-out-of-4 with Axial Blankets" storage configuration, virtually no information was provided concerning the simulations performed to make the comparison. (The staff believes that the indication in WCAP-16827-P, Addendum 1 that its simulations were made with the "4-out-of-4" storage configuration instead of the "4-out-of-4 with Axial Blankets" storage configuration is a typographical error.)

e) By comparing WCAP-16827-P Table 4-18 and WCAP-16827, Addendum 1 Figure 3-19 the staff believes the comparison in WCAP-16827, Addendum 1 is made using 5.0 w/o enriched fuel assemblies.

- **Given that as the case, there appears to be an unexplained 1500 pcm Δk_{eff} difference between the U^{235} 5.0 w/o enriched with 60 GWD/MTU burnup values in WCAP-16827-P Table 4-18 and WCAP-16827, Addendum 1 Figure 3-19. The difference is such that if the WCAP-16827-P Table 4-18 value were used the amount of non-conservatism at 60 GWD/MTU burnup would be approximately 1900 pcm rather than the 361 pcm indicated by WCAP-16827-P, Addendum 1.**
- **Since the dampening affect on the 'end effect' caused by the presence of axial blankets is believed to decrease as the delta between the nominal enrichment and the blanket enrichment decreases, comparisons similar to those performed in WCAP-16827, Addendum 1 should show lower peaks and earlier transition to negative margin for lower enrichments. Therefore the lower enrichments credited in the "4-out-of-4 with Axial Blankets" storage configuration may also have significant non-conservatisms.**

f) While the "4-out-of-4" storage configuration may be bounding with respect to the other storage configurations; that does not mean the result for those storage configurations will be zero. It appears that WCAP-16827, Addendum 1 made no effort to determine the effect on those storage configurations.

Therefore the staff requests the licensee determine the effect of using appropriate axial burnup profiles and that the burnup/enrichment loading curves be adjusted accordingly.

Response

The justification of the burnup profile used to represent blanketed assemblies is presented in this RAI response. A new justification is presented because of the concerns noted above by the staff.

Fuel assemblies with axial blankets have been used in CPNPP Units 1 and 2 since the third cycle of operation. Blankets of three different enrichments have been used: natural, 2.0 w/o, and 2.6 w/o. The enrichment of the blanket pellets in any given feed region is the same; there is no variability in blanket enrichment among fuel rods in an assembly or among assemblies in a reload batch. The blanket enrichment impacts the blanket reactivity, which in turn impacts the relative power and burnup of the blanket during assembly depletion. This necessitates a review of limiting assembly burnup profiles and reactivities as a function of blanket enrichment. All burnup shapes reviewed were well behaved.

Natural Enrichment Blankets

Axial blankets of natural enrichment uranium were used in several cycles at CPNPP Units 1 and 2 starting in Unit 1 Cycle 3. The low enrichment of the blanket leads to extremely low relative burnups, potentially less than 0.2, in the fuel assembly blanket. This low burnup is offset by the low reactivity of the natural enrichment fuel.

A review of the axial burnup profiles generated by assemblies with natural blankets was performed and limiting profiles were selected on the basis of low relative burnups in the top three nodes. Further clarification of the veracity of this technique is provided in the response to RAI 11. Two limiting shapes were identified: one for assembly average burnups at or below 40,000 MWd/MTU and one above. At high burnups, the axial burnup profile tends to flatten as the higher reactivity of the less depleted fuel near the top of the core draws power upward. The limiting burnup profile for assemblies below 40,000 MWd/MTU burnup was generated by a once-burned assembly with slightly less than 19,000 MWd/MTU burnup. The limiting profile for high burnup assemblies was generated by a twice-burned assembly with a burnup slightly greater than 42,000 MWd/MTU. The relative burnup profiles used in the 4-zone depletion models for both assemblies are provided in the table below. Further justification for the use of the 4-zone model is also provided in the response to RAI 11.

Relative Burnup Profiles for Assemblies with Natural Blankets

Node Midpoint (in)	Low Burnup (≤40,000 MWd/MTU)	High Burnup (>40,000 MWd/MTU)
141	0.129	0.189
135	0.654	0.753
129	0.881	0.948
63	1.064	1.053

A series of depletion calculations were performed using these two axial burnup profiles to compare discharged assembly reactivity in the "4-out-of-4 with Axial Blankets" to that predicted by the uniform burnup profile used in WCAP-16827. A range of burnups from 25,000 MWd/MTU to 55,000 MWd/MTU was considered for both 4 and 5 w/o enrichment fuel with natural blankets. The maximum burnup was selected as 55,000 MWd/MTU because this is approximately the highest depletion reached by a fuel assembly with natural blankets at CPNPP. Several significant conservatisms exist in these calculations. The largest is the use of 1.0 w/o enrichment in the blankets instead of 0.72 w/o. The core operating conditions are also conservative. These depletions were performed assuming uprated core operating temperatures and power levels, as well as a constant soluble boron concentration of 1000 ppm. The average boron concentration for these older cycles was significantly lower, typically less than 700 ppm. Positive reactivity margin was demonstrated at all burnup and enrichment combinations, as shown in the table below. The reported uncertainty is the root sum square of the uncertainties of the two KENO calculations. The increase in margin between 40,000 and 45,000 MWd/MTU burnup is a result of the less severe axial burnup profile associated with the high burnup assembly.

Margin Demonstrated for Fuel Assemblies with Natural Enrichment Axial Blankets

Enrichment (w/o)	Burnup (MWd/MTU)	Reactivity Margin (Δk_{eff})	Uncertainty (Δk_{eff})
4	25,000	0.01102	0.00019
	30,000	0.01034	0.00018
	35,000	0.00678	0.00019
	40,000	0.00132	0.00021
	45,000	0.00823	0.00020
	50,000	0.00454	0.00022
	55,000	0.00088	0.00023
5	25,000	0.01079	0.00018
	30,000	0.01182	0.00019
	35,000	0.01097	0.00020
	40,000	0.00785	0.00018
	45,000	0.01265	0.00019
	50,000	0.01073	0.00018
	55,000	0.00777	0.00018

2.0 w/o Blankets

Axial blankets of 2.0 w/o enriched uranium were used in several cycles at CPNPP Units 1 and 2 and have recently been superseded with 2.6 w/o blankets. The moderate enrichment of the blanket leads to low relative burnups, typically between 0.3 and 0.5, in the fuel assembly blanket. This low burnup is offset by the low reactivity of the enrichment of the fuel.

A review of the axial burnup profiles generated by assemblies with enriched blankets was performed and limiting profiles were selected on the basis of low relative burnups in the top three nodes. The profiles considered were end of cycle profiles from Unit 1 Cycles 10 – 14 and Unit 2 Cycles 8 – 11. Three limiting shapes were identified: one for assembly average burnups at or below 30,000 MWd/MTU, one for assembly average burnups between 30,000 and 45,000 MWd/MTU, and one for higher burnups. At high burnups, the axial burnup profile tends to flatten as the higher reactivity of the less depleted fuel near the top of the core draws power upward. The limiting burnup profile for assemblies below 30,000 MWd/MTU burnup was generated by a once-burned assembly with a 2.6 w/o blanket and slightly less than 17,000 MWd/MTU burnup. The results considering these 2.6 w/o blanket shapes at low burnup are presented below as part of the discussion of assemblies with 2.6 w/o blankets. The limiting profile for the middle burnup range was generated by a twice-burned assembly with a 2.0 w/o blanket and a burnup slightly under than 41,000 MWd/MTU. The higher burnup profile was generated by a twice-burned assembly with a 2.0 w/o blanket and a burnup of just over 45,000 MWd/MTU. The relative burnup profiles used for comparing the reactivity associated with these burnup profiles to the uniform profile used in WCAP-16827 were 7-zone models. The bottom nodes were used from the same assemblies selected based on low burnup in the top nodes. As was demonstrated in the response to RAI 11, the 7-zone model is slightly less conservative, but more realistic, than the 4-zone model. The relative burnup profiles used in the depletion calculations are given in the table below.

Relative Burnup Profiles for Assemblies with 2.0 w/o Blankets

Node Midpoint (in)	Intermediate Burnup (30,000 < BU < 45,000 MWd/MTU)	High Burnup (BU > 45,000 MWd/MTU)
141	0.321	0.347
135	0.743	0.771
129	0.916	0.923
72	1.102	1.095
15	1.010	1.016
9	0.827	0.856
3	0.346	0.374

A series of depletion calculations were performed using these two axial burnup profiles to compare discharged assembly reactivity in the "4-out-of-4 with Axial Blankets" storage configuration to that predicted by the uniform burnup profile used in WCAP-16827. A range of burnups from 30,000 MWd/MTU to 51,000 MWd/MTU was considered for 4 w/o fuel and a burnup range of 30,000 MWd/MTU to 63,000 MWd/MTU was considered for 5 w/o fuel. These upper limits are rounded up from the limits documented in WCAP-16827. The depletion calculations were carried out using uprated core operating temperatures and power as well as a constant soluble boron concentration of 1000 ppm. Positive reactivity margin was demonstrated for all conditions, as shown in the table below. The reported uncertainty is the root sum square of the uncertainties of the two KENO calculations.

Margin Demonstrated for Fuel Assemblies with 2.0 w/o Enrichment Axial Blankets

Enrichment (w/o)	Burnup (MWd/MTU)	Reactivity Margin (Δk_{eff})	Uncertainty (Δk_{eff})
4	30,000	0.01572	0.00021
	35,000	0.01246	0.00018
	40,000	0.00805	0.00022
	45,000	0.00268	0.00023
	50,000	0.00146	0.00021
	51,000	0.00095	0.00023
5	30,000	0.01808	0.00019
	35,000	0.01836	0.00019
	40,000	0.01644	0.00019
	45,000	0.01247	0.00021
	50,000	0.01165	0.00022
	55,000	0.00728	0.00022
	60,000	0.00252	0.00022
	63,000	0.00039	0.00023

The theoretical density modeled for the assemblies with 2.0 w/o blankets was lowered to 95.5% from the 97.5% used in WCAP-16827. The maximum theoretical density allowed is [ ]^{a,c}, so only a theoretical density change of only [ ]^{a,c} needs to be accounted for as an additional uncertainty. The results provided in the table below demonstrate that the uncertainty related to this change in theoretical density is 0.00131 Δk_{eff} units. When this uncertainty is statistically combined with the other uncertainties, including the burnup measurement and depletion uncertainties discussed in response to RAI 17, the impact on the overall sum of biases and uncertainties is less than 0.00010 Δk_{eff} units. Sufficient positive margin exists at all enrichment and burnup combinations to account for this increased uncertainty.

Uncertainty Associated with Reduced Theoretical Density

Case	$k_{eff} \pm \sigma$	Δk_{eff}
[ ]^{a,c} Theoretical Density	0.96423 ± 0.00023	
95.5% Theoretical Density	0.96340 ± 0.00025	0.000131

<u>2.6 w/o Blankets</u>

Axial blankets of 2.6 w/o enriched uranium have been used in the past several cycles at CPSES Units 1 and 2 and will be used in uprated cycles. The moderate enrichment of the blanket leads to low relative burnups, typically between 0.4 and 0.5, in the fuel assembly blanket. This low burnup is partially offset by the reduced reactivity associated with the enrichment of the blanket.

A review of the axial burnup profiles generated by assemblies with 2.6 w/o blankets was performed and limiting profiles were selected on the basis of low relative burnups in the top three nodes. The profiles considered were end of cycle profiles from Unit 1 Cycles 10 – 14 and Unit 2 Cycles 8 – 11. Two limiting shapes were identified: the worst case shape over all burnups and the most adverse profile that occurs above or not more than 10,000 MWd/MTU below the burnup limit for the enrichment of the assembly being considered. The worst case burnup profile is the low burnup profile discussed above. The most adverse shape near or in excess of the burnup limit comes from a thrice-burned 4.5 w/o assembly with 47,231 MWd/MTU burnup. The 4.5 w/o burnup limit, as determined from Table 5-2 of WCAP-16827, is 57,003 MWd/MTU. Some conservatism is included in this calculation by the use of this shape because the additional 9772 MWd/MTU burnup needed to make this assembly meet the requirements of this storage configuration would likely flatten the profile significantly. The 7-zone model was used for comparing the reactivity associated with these burnup profiles to the uniform profile used in WCAP-16827. The bottom nodes were used from the same assemblies selected based on low burnup in the top nodes. As was demonstrated in the response to RAI 11, the 7-zone model is slightly less conservative, but more realistic, than the 4-zone model.

Relative Burnup Profiles for Assemblies with 2.6 w/o Blankets

Node Midpoint (in)	All Burnups	Within 10,000 MWd/MTU of Respective Limit
141	0.375	0.438
135	0.681	0.745
129	0.878	0.917
72	1.109	1.092
15	0.966	0.987
9	0.753	0.807
3	0.393	0.453

A series of depletion calculations were performed using these two axial burnup profiles to compare discharged assembly reactivity in the "4-out-of-4 with Axial Blankets" storage configuration to that predicted by the uniform burnup profile used in WCAP-16827. A range of burnups from 20,000 MWd/MTU to 55,000 MWd/MTU was considered for 4 w/o fuel and a burnup range of 20,000 MWd/MTU to 67,000 MWd/MTU was considered for 5 w/o fuel. These upper limits are discussed below. The depletion calculations were carried out using uprated core operating temperatures and power as well as a constant soluble boron concentration of 1000 ppm. Positive margin cannot be demonstrated at high burnups with these conservative shapes. Significant margin does exist at low burnups, so it is evident that assemblies with 2.0 w/o blankets need not be considered at burnups below 30,000 MWd/MTU. The reported uncertainty is the root sum square of the uncertainties of the two KENO calculations.

Margin Demonstrated for Fuel Assemblies with 2.6 w/o Enrichment Axial Blankets in the "4-out-of-4 with Axial Blankets" Storage Configuration

Enrichment (w/o)	Burnup (MWd/MTU)	Reactivity Margin (Δk_{eff})	Uncertainty (Δk_{eff})
4	20,000	0.01322	0.00018
	25,000	0.01181	0.00021
	30,000	0.00916	0.00020
	35,000	0.00029	0.00021
	40,000	0.00392	0.00022
	45,000	-0.00143	0.00022
	50,000	-0.00691	0.00023
	55,000	-0.01187	0.00024
5	20,000	0.01376	0.00018
	25,000	0.01488	0.00018
	30,000	0.01353	0.00019
	35,000	0.01090	0.00021
	40,000	0.01373	0.00022
	45,000	0.00994	0.00021
	50,000	0.00541	0.00021
	55,000	0.00052	0.00023
	60,000	-0.00448	0.00023
	65,000	-0.00905	0.00021
	67,000	-0.01074	0.00025

Because the staff has disagreed with the use of this reactivity penalty as an uncertainty, as stated in RAI 10, a bias is determined as a function of enrichment to account for this potential non-conservatism. The reactivity penalties presented in the table below are increased to 0.011 Δk_{eff} for 5 w/o and 0.012 Δk_{eff} for 4 w/o. Based on this trend, a penalty of 0.013 Δk_{eff} is added for 3 w/o fuel. After the addition of the burnup shape penalty, the burnup limits for 4 and 5 w/o fuel, respectively, are 54,543 and 66,355 MWd/MTU. The burnups at which the penalties are determined is therefore conservatively higher than the limit. It should also be noted that these penalties are applied to all fuel assemblies in the "4-out-of-4 with Axial Blankets" storage configuration regardless of the enrichment of the blanket. This provides significant conservatism for the natural and 2.0 w/o enrichment blanket assemblies.

The analysis described above used a limiting burnup profile based on assemblies within 10,000 MWd/MTU of the burnup limit for the "4-out-of-4 with Axial Blankets" configuration. A similar analysis was performed for the "3-out-of-4 with Axial Blankets" configuration because of the lower burnups required in this configuration. For these calculations, only the single low burnup profile was considered. A range of burnups from 20,000 MWd/MTU to 33,000 MWd/MTU was considered for 4 w/o fuel and a burnup range of 20,000 MWd/MTU to 44,000 MWd/MTU was considered for 5 w/o fuel. The upper limits of this range bound the burnup limits determined based on the response to RAI 17 which are 32,732 MWd/MTU and 43,164 MWd/MTU. Positive margin was demonstrated for all enrichment and burnup combinations, so no penalty is required for the "3-out-of-4 with Axial Blankets" configuration. The reported uncertainty is the root sum square of the uncertainties of the two KENO calculations.

Margin Demonstrated for Fuel Assemblies with 2.6 w/o Enrichment Axial Blankets in the "3-out-of-4 with Axial Blankets" Storage Configuration

Enrichment (w/o)	Burnup (MWd/MTU)	Reactivity Margin (Δk_{eff})	Uncertainty (Δk_{eff})
4	20,000	0.01241	0.00023
	25,000	0.01030	0.00023
	30,000	0.00598	0.00023
	35,000	0.00228	0.00023
5	20,000	0.01270	0.00023
	25,000	0.01370	0.00023
	30,000	0.01236	0.00023
	35,000	0.00912	0.00027
	40,000	0.00465	0.00023
	44,000	0.00021	0.00023

It may be noted that the identified margin at 5 w/o and 44,000 MWd/MTU burnup is statistically insignificant. Based on the loss of margin between 40,000 and 44,000 MWd/MTU depletion, it can be concluded that statistically significant margin has been demonstrated at the burnup limit of 43,164 MWd/MTU.

Question 17

In the Kopp Letter (Reference 8), the NRC staff provided guidance for determining the burnup uncertainty: "A reactivity uncertainty due to uncertainty in the fuel depletion calculations should be developed and combined with other calculational uncertainties. In the absence of any other determination of the depletion uncertainty, an uncertainty equal to 5 percent of the reactivity decrement to the burnup of interest is an acceptable assumption." The 5 percent reactivity decrement has been used throughout the industry since the issuance of the Kopp Letter. Rather than use the 5 percent reactivity decrement as the burnup uncertainty, the WCAP-16827-P analysis used a 5 percent decrease in the burnup of interest. In actuality the methodology performs a simulation at three different burnup levels and fits that data with a second order polynomial. The methodology then takes the derivative of that polynomial to find the equation for the line tangent to the curve at the point of the burnup being credited and then uses that equation to find a Δk_{eff} from a Δburnup. The Δburnup is set equal to 5 percent of the burnup being credited. This Δk_{eff} is then applied as the Burnup Uncertainty. The staff found this methodology unacceptable for the Prairie Island SFP criticality amendment (Reference 9) and the Beaver Valley criticality amendment (Reference 10). During the April 24th teleconference, the staff clearly indicated to the licensee that use of this methodology for calculating the Burnup Uncertainty had been previously rejected by the staff. The licensee's vendor indicated that they had additional information that had not yet been supplied to the staff and the new information would allow the staff to accept the alternative methodology. The staff informed the licensee that approval of the new information supporting the alternate methodology would be precedent setting and take additional time. Despite the assurances that new information would be provided in the supplement, the information concerning the Burnup Uncertainty in WCAP-16827, Addendum 1 is virtually identical to the information the vendor provided for the Beaver Valley criticality amendment. The staff finds this information to be insufficient. Therefore the staff requests the licensee provide a revised analysis that determines and applies the Burnup Uncertainty in accordance with staff guidance. Since the CPSES, Units 1 and 2 analysis credits such large amounts of burnup, the staff does not believe there is sufficient analytical margin to accommodate the increase in Burnup Uncertainty. Therefore, the staff requests the burnup/enrichment loading curves be adjusted accordingly.

Response

Following discussions among the staff, the licensee, and the licensee's vendor on November 13, 2008, and December 17, 2008, it was agreed that the response to this RAI would include justification for both the burnup measurement and depletion uncertainties. Much of the information relating to the burnup measurement uncertainty has been provided previously, but it is provided below for completeness. Some changes have also been incorporated since previous submittals.

Burnup Measurement Uncertainty

A burnup measurement uncertainty will be developed based on an assembly *power* uncertainty. The individual factors that contribute to the assembly power uncertainty will vary during the depletion of the assembly, so this instantaneous power uncertainty will provide a conservative upper bound of a burnup measurement uncertainty.

Three general terms are used to construct an overall assembly power uncertainty: the assembly power peaking uncertainty, the core power uncertainty, and the assembly loading uncertainty. The assembly power peaking and core power uncertainties are statistically convoluted because the error in the power, both assembly peaking and absolute core power level, is likely to vary over a single cycle and from cycle to cycle. This is a valid assumption when considering an assembly burnup uncertainty because almost every assembly is in the core for two or three cycles. The assembly loading uncertainty is considered as a bias because its value is fixed and never varies after fabrication.

The assembly power peaking uncertainty is derived from the $F_{\Delta H}$ uncertainty because $F_{\Delta H}$ represents the axially integrated power for a single rod. The 95/95 value for the uncertainty in $F_{\Delta H}$ from Reference 1 is [ ]^{a,c}. This uncertainty includes a component for the uncertainty of the rod power for a given assembly power, referred to as the radial local peaking uncertainty or pin-to-box uncertainty, of [ ]^{a,c}. This uncertainty can be removed because the uncertainty of interest is the assembly power, so radial variations within the assembly have no impact. Because the radial local uncertainty was statistically convoluted and increased by a 95/95 multiplier (from Reference 1), the assembly power peaking uncertainty is calculated, as shown in Equation 1, to be approximately [ ]^{a,c}.

$$\sigma_A = \sqrt{\sigma_{Fdh}^2 - \left(\sigma_{RLP} \times M_{95/95}\right)^2} = \Big[\qquad \Big]^{a,c} \qquad \text{Eqn (1)}$$

Where: σ_A is the assembly power peaking uncertainty
σ_{Fdh} is the $F_{\Delta H}$ uncertainty
σ_{RLP} is the uncertainty on radial local peaking
$M_{95/95}$ is the appropriate 95/95 multiplier

The licensed value of the calorimetric uncertainty at CPSES units 1 and 2 was 2% until license amendments in 2001 reduced this uncertainty to 0.6%. The same flow meters have been used at both units for all cycles of operation, so this lower uncertainty would in principle be applicable to all cycles. No credit is taken for this, however, and 2% is used for the calorimetric uncertainty as an additional conservatism in the development of the burnup measurement uncertainty.

The uncertainty in uranium loading in an assembly is assumed to be 0.2%. The data to support this value as conservative exist in the DOE/NRC Form 741 sent with each fuel shipment. The uncertainty reported for one shipment of Westinghouse 17 x 17 standard fuel, the limiting fuel type in the WCAP-16827 analysis, shows an overall uranium loading uncertainty of 0.05%, which is one-quarter of the value assumed in these calculations. It can be safely concluded that the 0.2% uncertainty in uranium loading is bounding.

The assembly power uncertainty is finally calculated as shown below in Equation 2.

$$F_{APOW} = \sqrt{\left(\sigma_A^2 + \sigma_{cal}^2\right)} + \sigma_{MTU} = [\qquad\qquad]^{a,c} \qquad \text{Eqn (2)}$$

Where: F_{APOW} is the estimated assembly power uncertainty
σ_A is the assembly power peaking uncertainty
σ_{cal} is the calorimetric uncertainty
σ_{MTU} is the uranium loading bias

The value of [$]^{a,c}$ will be used to determine the burnup measurement uncertainty using the same differential formulation as reported in WCAP-16827 and shown below in Equation 3.

$$\Delta k_{BU} = \left([\qquad]^{a,c}(MaxBU)\right) \cdot \left(\frac{\partial k}{\partial BU}(MaxBU)\right) \qquad \text{Eqn (3)}$$

Where: Δk_{BU} is the burnup measurement uncertainty
MaxBU is the maximum credited burnup

It should be reiterated that the power uncertainty estimated here is higher than a corresponding burnup uncertainty because of the integration of the random variation about the mean value over the life of the assembly. Conservatism also exists in the assumed calorimetric uncertainty and uranium loading uncertainty.

Depletion Uncertainty

The depletion uncertainty methodology from Reference 2 has been adopted for the CPSES Units 1 and 2 spent fuel pool criticality safety analysis. This methodology states that an acceptable assumption for the depletion uncertainty is 5% of the reactivity decrement credited to burnup.

The uncertainty is calculated for each enrichment in each configuration as the difference between the calculated k_{eff} with fresh fuel and the target k_{eff} for that enrichment and configuration. This creates recursive relationship between the depletion uncertainty and the target k_{eff}, which is solved by iteration until the depletion uncertainty changes by less than 0.00001 Δk_{eff} units. The burnup dependent portion of the bias and uncertainty rackup is shown below for all five configurations considered as part of this license amendment request.

Burnup Dependent Uncertainties for the "4-out-of-4" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Enrichment Uncertainty	BU Measurement Uncertainty	Depletion Uncertainty	Total Biases and Uncertainties	Target k_{eff}
1.02	0.01916	0 ^{a,c}	0	0.02470	0.97030
2	0.00812		0.01224	0.02165	0.97335
3	0.00522		0.01854	0.02626	0.96874
4	0.00396		0.02233	0.02994	0.96506
5	0.00171		0.02482	0.03168	0.96332

Burnup Dependent Uncertainties for the "4-out-of-4 with Axial Blankets" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Enrichment Uncertainty	BU Measurement Uncertainty	Depletion Uncertainty	Total Biases and Uncertainties	Target k_{eff}
3	0.00522	a, c	0.01925	0.04049	0.95451
4	0.00396		0.02300	0.04343	0.95157
5	0.00171		0.02549	0.04507	0.94993

Burnup Dependent Uncertainties for the "3-out-of-4" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Enrichment Uncertainty	BU Measurement Uncertainty	Depletion Uncertainty	Total Biases and Uncertainties	Target k_{eff}
1.47	0.01150	0 a, c	0	0.01789	0.97711
2	0.00814		0.00469	0.01662	0.97838
3	0.00462		0.01034	0.01871	0.97629
4	0.00353		0.01376	0.02148	0.97352
5	0.00258		0.01609	0.02350	0.97150

Burnup Dependent Uncertainties for the "3-out-of-4 with Axial Blankets" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Enrichment Uncertainty	BU Measurement Uncertainty	Depletion Uncertainty	Total Biases and Uncertainties	Target k_{eff}
3	0.00462	a, c	0.01036	0.01907	0.97593
4	0.00353		0.01379	0.02209	0.97291
5	0.00258		0.01614	0.02456	0.97044

Burnup Dependent Uncertainties for the "2-out-of-4" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Enrichment Uncertainty	BU Measurement Uncertainty	Depletion Uncertainty	Total Biases and Uncertainties	Target k_{eff}
3.67	0.00329	0 a, c	0	0.01962	0.97538
4	0.00279		0.00084	0.01954	0.97546
5	0.00173		0.00281	0.01976	0.97524

Updated burnup limits are provided for all enrichments in all five storage configurations considered in this license amendment request even though the impact of the more conservative methodology for determining the depletion uncertainty is less than the reserved administrative margin for some enrichments in some configurations. The burnup limits for the "4-out-of-4 with Axial Blankets" storage configuration are also adjusted as described in the response to RAI 12.

Question 26

In determining the soluble boron requirements for CPSES, Units 1 and 2, WCAP-16827-P states, "...soluble boron credit methodology utilized here is identical to that followed in Reference 1." Reference 1 is Reference 14 herein. However, it does not appear to be true. While there are some similarities between what was done in WCAP-16827-P and Reference 14, they certainly are not identical and there are enough significant differences such that the Reference 14 is not an appropriate precedent for what was done in WCAP-16827-P. WCAP-16827-P determined the soluble boron requirements for the "4-out-of-4" storage configuration using 5.0 w/o enriched fuel assembly with 75,759 MWD/MTU of burnup. An implicit assumption is that this storage configuration with this burnup/enrichment is limiting with respect to all other storage configurations and burnup/enrichment combinations within WCAP-16827-P. Rather than an infinite array of "4-out-of-4" storage configurations, the soluble boron credit methodology is modeled as the SFP Region II full of "4-out-of-4" storage configurations. The WCAP-16827-P soluble boron credit methodology determines the k_{eff} of the model at eleven points ranging from 0 PPM to 1024 PPM. A Δk_{eff} term is determined for the ten soluble boron amounts with respect to 0 PPM. The Δk_{eff} terms are fit to a second order polynomial with respect to soluble boron concentration. That polynomial is used to individually find the soluble boron concentration to accommodate three separate Δk_{eff} factors. Those factors are 0.05 Δk_{eff}, a Δk_{eff} for uncertainties, and the Δk_{eff} required to offset the largest reactivity increase due to worst case accident/abnormal conditions. The soluble boron required to maintain the SFP k_{eff} less than 0.95 under nominal conditions is the summation of the first two factors. The licensee must be able to demonstrate the ability to detect and terminate a SFP boron dilution event before reaching this soluble boron concentration. This value is typically located in the Design Features section of the Technical Specifications. The soluble boron required to maintain the SFP k_{eff} less than 0.95 under accident/abnormal conditions is the summation of all three. This value is typically the basis for a SFP minimum soluble boron concentration limiting condition for operation (LCO). The first factor in the WCAP-16827-P soluble boron methodology has several implicit assumptions. One is that the storage configuration is already at a k_{eff} less than 1.0. A second is that the total 'rackup' of biases and uncertainties is unchanged by the presence of soluble boron in the moderator. The second factor includes a 'depletion uncertainty' and a 'burnup measurement uncertainty.' The 'burnup measurement uncertainty is identical to that used previously. The 'depletion uncertainty' is a new item, used only in the soluble boron credit determination. The third factor accounts for accident/abnormal conditions. The staff previously identified several non-conservative aspects of this methodology. Those were discussed with the licensee during April 24th conference call. WCAP-16827-P, Addendum 1 provided some additional information regarding the soluble boron credit methodology. It indicates that the above soluble boron credit methodology was applied to each storage configuration, but ultimately simulations were performed with soluble boron present with the biases and uncertainties applied afterward. The WCAP-16827-P, Addendum 1 method indicates that > 1900 PPM of soluble boron is required to maintain keff ≤ 0.95 under all conditions, as compared to the 1600 PPM indicated by WCAP-16827-P. WCAP-16827-P, Addendum 1 also indicates that the "2-out-of-4" storage configuration requires a higher soluble boron concentration

rather than the "4-out-of-4" storage configuration, as was assumed in WCAP-16827-P. To further evaluate the soluble boron credit requirements for CPSES, Units 1 and 2, the licensee is requested to provide the following information. (Note storage configurations crediting RCCA or RackSavers are not included in this request for additional information.)

a) WCAP-16827-P, Addendum 1 continues to assume the biases and uncertainties are unaffected by the presence of a large amount of soluble boron. What affect does the presence of 1600 PPM and 1900 PPM of soluble boron have on the biases and uncertainties?

b) The analysis states that increased temperature induced a negative reactivity effect. Was that determination made with or without soluble boron present in the SFP?

c) WCAP-16827-P, Addendum 1 discusses additional simulations that were performed to support the analysis, which differed from the WCAP-16827-P methodology, and provides the keff results in Table 3-4. Please provide a description of those simulations. Include the parameters used and any modeling differences with respect to WCAP-16827-P. Also, clarify if the results stated in Table 3-4 are for 1600 PPM or 1900 PPM of soluble boron.

d) WCAP-16827-P, Addendum 1 discusses the results of the simulations performed on two storage configuration. One contains two RCCAs; the other is the "2-out-of-4" storage configurations, which resulted in the largest soluble boron requirement. The biases and uncertainties for each are handled differently. Please state the reasons.

- **The discussion of the "2-out-of-4" storage configuration applies the "standard" biases and uncertainties from WCAP-16827-P, Table 4-16 and the 'burnup measurement uncertainty' from WCAP-16827-P, Table 4-16, but does not apply the 'depletion uncertainty.' Also, should a 'depletion uncertainty' be applied it is likely that any remaining reserved analytical margin would be completely eroded. Please justify.**

e) WCAP-16827-P, Addendum 1 indicates that > 1900 PPM of soluble boron is required to maintain keff ≤ 0.95 under all conditions. As CPSES, Units 1 and 2 TS 4.3.1.1.c lists the amount of soluble boron required to maintain keff ≤ 0.95 under nominal conditions. What is the amount of soluble boron required to maintain keff ≤ 0.95 under nominal conditions using the methodology of WCAP-16827-P, Addendum 1? If necessary, provide a revised TS proposal that incorporates this value.

WCAP-16827-P, Addendum 1 credits a portion of the 0.005 Δk_{eff} reserved analytical margin to offset the amount of soluble boron required above 1900 PPM. 1900 PPM is close to the CPSES, Units 1 and 2, TS 3.7.16 minimum SFP soluble boron requirement of 2000 PPM. Please describe the process used to determine that SFP is at the proper soluble boron concentration.

Response

As discussed in the response to Question 17, 5% of the credited reactivity decrement will be used for the depletion uncertainty for the CPNPP Units 1 and 2 spent fuel pool criticality safety analysis. The depletion uncertainty will be included in uncertainty rackup at both borated and unboarated conditions, allowing the soluble boron concentration necessary to satisfy the requirements of 10CFR50.68 to be calculated via direct simulation. A subsequent submittal will be provided detailing the methodology and results of these calculations.

Question 28

Please state why the 'depletion uncertainty' is not applied to the unborated portion of the analysis?

Response

As discussed in the response to Question 17, the depletion uncertainty will be determined for the CPNPP Units 1 and 2 spent fuel pool criticality safety analysis as 5% of the credited reactivity change due to burnup. The depletion uncertainty will be included in both the unborated and borated portions of the analysis.

Minimum Required Assembly-Average Burnup versus Initial ^{235}U Enrichment and Decay Time for the "4-out-of-4" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Assembly Average Burnup (MWd/MTU)				
	0 yr Decay	5 yr Decay	10 yr Decay	15 yr Decay	20 yr Decay
1.02	0	0	0	0	0
2.0	25889	22850	21148	20003	19267
3.0	45171	40776	38092	36314	34953
4.0	62707	57525	54192	51815	50188
5.0	79019	73042	69083	66274	64463

The required assembly burnup as a function of ^{235}U enrichment and decay time in the "4-out-of-4" storage configuration is described by the following polynomials:

$$\text{Assembly BU (0 years)} = -208.42\ e^4 + 3004.72\ e^3 - 16452.33\ e^2 + 58001.39\ e - 45007.42$$

$$\text{Assembly BU (5 years)} = -182.34\ e^4 + 2543.36\ e^3 - 13449.60\ e^2 + 48701.86\ e - 38184.57$$

$$\text{Assembly BU (10 years)} = -177.18\ e^4 + 2419.60\ e^3 - 12453.18\ e^2 + 44753.60\ e - 35068.28$$

$$\text{Assembly BU (15 years)} = -150.04\ e^4 + 2062.25\ e^3 - 10713.45\ e^2 + 40448.25\ e - 32136.99$$

$$\text{Assembly BU (20 years)} = -171.45\ e^4 + 2315.66\ e^3 - 11637.03\ e^2 + 41018.16\ e - 32003.15$$

Minimum Required Assembly-Average Burnup versus Initial ^{235}U Enrichment and Decay Time for the “4-out-of-4 with Axial Blankets” Storage Configuration

Initial Enrichment (w/o ^{235}U)	Assembly Average Burnup (MWd/MTU)				
	0 yr Decay	5 yr Decay	10 yr Decay	15 yr Decay	20 yr Decay
3.0	41695	37473	34771	32922	31600
4.0	54543	49711	46619	44425	42863
5.0	66355	61032	57620	55072	53386

The required assembly burnup as a function of ^{235}U enrichment and decay time in the “4-out-of-4 with Axial Blankets” storage configuration is described by the following polynomials:

$$\text{Assembly BU (0 years)} = -517.99\ e^2 + 16474.00\ e - 3064.99$$

$$\text{Assembly BU (5 years)} = -458.50\ e^2 + 15447.51\ e - 4743.00$$

$$\text{Assembly BU (10 years)} = -423.50\ e^2 + 14812.50\ e - 5855.00$$

$$\text{Assembly BU (15 years)} = -427.99\ e^2 + 14499.00\ e - 6722.99$$

$$\text{Assembly BU (20 years)} = -370.00\ e^2 + 13853.01\ e - 6629.00$$

Minimum Required Assembly-Average Burnup versus Initial ^{235}U Enrichment and Decay Time for the "3-out-of-4" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Assembly Average Burnup (MWd/MTU)				
	0 yr Decay	5 yr Decay	10 yr Decay	15 yr Decay	20 yr Decay
1.47	0	0	0	0	0
2.0	8835	8272	7944	7727	7443
3.0	22048	20516	19587	18909	18460
4.0	35432	33076	31563	30621	29819
5.0	48156	45305	43440	42193	41181

The required assembly burnup as a function of ^{235}U enrichment and decay time in the "3-out-of-4" storage configuration is described by the following polynomials:

$$\text{Assembly BU (0 years)} = -301.95\, e^4 + 4088.58\, e^3 - 20104.01\, e^2 + 55676.35\, e - 49978.94$$

$$\text{Assembly BU (5 years)} = -294.45\, e^4 + 4014.44\, e^3 - 19777.14\, e^2 + 53994.30\, e - 48012.16$$

$$\text{Assembly BU (10 years)} = -284.05\, e^4 + 3904.46\, e^3 - 19350.47\, e^2 + 52673.46\, e - 46691.71$$

$$\text{Assembly BU (15 years)} = -310.09\, e^4 + 4229.35\, e^3 - 20743.80\, e^2 + 54698.77\, e - 47568.50$$

$$\text{Assembly BU (20 years)} = -256.53\, e^4 + 3535.12\, e^3 - 17536.25\, e^2 + 48205.74\, e - 42999.81$$

Minimum Required Assembly-Average Burnup versus Initial ^{235}U Enrichment and Decay Time for the "3-out-of-4 with Axial Blankets" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Assembly Average Burnup (MWd/MTU)				
	0 yr Decay	5 yr Decay	10 yr Decay	15 yr Decay	20 yr Decay
3.0	21558	19999	19017	18337	17810
4.0	32732	30559	28988	27961	27223
5.0	43164	40342	38397	37019	36124

The required assembly burnup as a function of ^{235}U enrichment and decay time in the "3-out-of-4 with Axial Blankets" storage configuration is described by the following polynomials:

$$\text{Assembly BU (0 years)} = -370.99\, e^2 + 13771.00\, e - 16415.99$$

$$\text{Assembly BU (5 years)} = -388.49\, e^2 + 13279.50\, e - 16342.99$$

$$\text{Assembly BU (10 years)} = -280.99\, e^2 + 11938.00\, e - 14267.99$$

$$\text{Assembly BU (15 years)} = -282.99\, e^2 + 11605.00\, e - 13930.99$$

$$\text{Assembly BU (20 years)} = -255.99\, e^2 + 11205.00\, e - 13500.99$$

Minimum Required Assembly-Average Burnup versus Initial ^{235}U Enrichment and Decay Time for the "2-out-of-4" Storage Configuration

Initial Enrichment (w/o ^{235}U)	Assembly Average Burnup (MWd/MTU)
3.67	0
4.0	1536
5.0	6718

The required assembly burnup as a function of ^{235}U enrichment and decay time in the "2-out-of-4" storage configuration is described by the following polynomials:

$$\text{Assembly BU} = 396.58 \quad e^2 \quad + \quad 1612.75 \quad e \; - \; 11260.36$$

References

1. "Evaluation of Nuclear Hot Channel Factor Uncertainties," WCAP-7308-L-P-A, June 1988.

2. Laurence Kopp (USNRC), "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," August 19, 1998.

ENCLOSURE TO TXX-09001

Westinghouse authorization letter CAW-09-2521 with accompanying affidavit, Proprietary Information Notice and Copyright Notice.

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January 21, 2009

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: WPT-17280 (with attachments), "Power Uprate Project – SFP Criticality Analysis RAIs, Response to NRC Request for Additional Information" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-09-2521 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Luminant Generation Company LLC.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-09-2521, and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

W. J. Smoody

W. J. Smoody, Acting Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: G. Bacuta, NRC OWFN 12E-1

bcc: J. A. Gresham (ECE 4-7A) 1L
R. Bastien, 1L (Nivelles, Belgium)
C. Brinkman, 1L (Westinghouse Electric Co., 12300 Twinbrook Parkway, Suite 330, Rockville, MD 20852)
RCPL Administrative Aide (ECE 4-7A) 1L, 1A (letter and affidavit only)
R. Morrison (ECE 4-7A) 1L, 1A

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared R. M. Span, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

R. M. Span

R. M. Span, Principal Engineer
Regulatory Compliance & Plant Licensing

Sworn to and subscribed before me
this 21st day of January, 2009

Sharon L. Markle

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Sharon L. Markle, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 29, 2011
Member, Pennsylvania Association of Notaries

(1) I am Principal Engineer, Regulatory Compliance & Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse "Application for Withholding" accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in attachments to WPT-17280, "Power Uprate Project – SFP Criticality Analysis RAIs, Response to NRC Request for Additional Information" (Proprietary), dated January 21, 2009, for Comanche Peak Nuclear Power Plant Units 1 and 2, being transmitted by Luminant Generation Company LLC letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted for use by Westinghouse for Comanche Peak Nuclear Power Plant Units 1 and 2 is expected to be applicable for other licensee submittals in response to certain NRC requirements for justification of spent fuel pool criticality safety analysis.

This information is part of that which will enable Westinghouse to:

(a) Provide information in support of plant power spent fuel pool criticality safety analysis.

(b) Provide customer specific calculations.
(c) Provide licensing support for customer submittals.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for licensing documentation associated with spent fuel pool criticality safety analysis submittals.

(b) Westinghouse can sell support and defense of the technology to its customer in the licensing process.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar information and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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