

John Giessner

From: John Giessner
Sent: Friday, August 08, 2008 7:09 PM
To: Ross Telson; John Ellegood
Subject: FW: signed evaluation for SFP racks
Attachments: crs4.pdf

Here is a signed document , but has not been approved by site folks (the signers are not Palisades folks). I'm told there is a CR - just submitted - for a non-conservative assumption in one of the codes, but (I'm told) doe not impact the conclusion. I'll send that when I find it.

jack

From: Lahti, Laurie A. [mailto:llahti@entergy.com]
Sent: Friday, August 08, 2008 7:43 PM
To: John Giessner
Subject: signed evaluation for SFP racks

<<crs4.pdf>>

This was attached to a CR that was written today. I can discuss this with you when you have some time.

Laurie

Evaluation of the Palisades Degraded Region I Racks

The CASMO multi-group integral transport theory code system was employed to evaluate the reactivity impact of a potential loss of neutron absorber material in the Palisades Region I racks. The CASMO code system is the industry standard method for evaluating the reactivity effects on fuel storage systems due to variations in rack or fuel design material parameters. Additionally, it is also widely used to perform fuel burnup calculations. CASMO-3 was used in the original design analysis for these racks. CASMO-4 is used for this evaluation since it contains an improved neutron transport solution and updated nuclear library.

The design bases analysis of the Region I racks assumes the racks contained fresh unirradiated fuel with an initial enrichment of 4.95 w/o U-235. The neutron absorber (carborundum) assumed in the design bases analysis had a nominal B-10 areal density of 0.917 g/cm^2 . A CASMO-4 calculation was performed using the design bases assumptions, producing a K_{inf} of 0.9199. Configurations with reactivity values below this value are considered to be bound by the design bases configuration and will meet the 0.95 k-effective acceptance criteria.

Credit for fuel enrichment below design bases assumption

Due to core operating limit constraints, the Palisades fuel assembly designs are well below the fuel enrichment limit of 4.95 w/o U-235. The maximum bundle enrichment employed to date is 4.54 w/o U-235. Analysis of the reactivity of this bundle in the rack at 0.0 burnup produced a K_{inf} of 0.9059. The Region I rack currently contains lower enriched fuel with significant burnup.

Credit for Burned Assemblies Presently in Region I:

A review of the current Region I loading identified the limiting fuel assemblies noted in Table 1. The lowest burnup assembly in Region I is B069 at 5.139 GWD/MTU. In order to simplify the evaluation, a 5.0 GWD/MTU burnup is applied to the maximum enrichment assembly (4.54 w/o) that has been employed at Palisades. This approach is extremely conservative since the low burnup assemblies have lower enrichment and the higher enrichment assemblies have higher burnup. A conservative moderator temperature of 20 deg-C/68 deg-F was assumed. No Xenon is assumed to be present and the long term decay of fission products, which further reduce reactivity, is not credited. The resulting CASMO K_{inf} is 0.8698 based on nominal neutron absorber B-10 areal density. When the analysis is repeated with 50 % loss of the neutron absorber the K_{inf} increases to 0.8921.

Since the design bases analysis did not include burnup, an allowance for the uncertainties associated with burnup is applied. A conservative allowance of 0.005 delta-k was developed in reference 1 for high burnup fuel. The uncertainty is significantly less than the low burnup assumed in this evaluation. This evaluation assumes a uniform axial

burnup profile. As described in reference 2, this assumption is conservative for low-burnup fuel (i.e. less than 20 GWD/MTU).

Including the burnup uncertainty, the K_{inf} is 0.8971 which is well below the acceptance criteria of 0.9199 established above. Therefore the current pool configuration is less reactive than the configuration assumed in the initial analysis and the 0.95 k-effective criteria is met without credit for boron. Table 2 summarizes these results.

Table 1: Region I High Reactivity Fuel

Assembly ID	Initial Assembly Enrichment (w/o U-235)	Discharge Burnup (GWD/MTU)
B069	2.43	5.139
C139	3.05	6.343
K65	3.24	26.010
S10	4.19	34.491

Table 2: Summary of Evaluation Results

Case A	CASMO-4 results corresponding to analysis of record configuration (meets the 0.95 k-effective without credit for boron)	0.9199
Case B	Enrichment set to maximum value used at Palisades E= 4.54 w/o U-235	0.9059
Case C	Case B + 5.0 GWD/MTU Burnup	0.8698
Case D	Case C + Reduction of absorber material to 50% B-10 areal density	0.8921
Case E	Case D + Allowance for Burnup Uncertainty	0.8971

Following the original Badger test results at Palisades, the calibration cell was modified to be based on a B-10 areal density of 0.0566 g/cm^2 . The count rates from the modified calibration cell appear to bound the 38 panels tested during the campaign, however the data analysis continues, including correction for measurement uncertainties. The assumption of 50 % reduction in B-10 areal density corresponds to a 0.0458 g/cm^2 which was selected as a conservative value relative to the revised calibration cell.

An evaluation of the potential reactivity effect of voiding due to gas accumulation in the annulus region containing the neutron absorbers was also conducted. This volume contains vent holes and as expected, gas bubbles were observed to escape the rack during the Badger test so significant gas accumulation is not considered likely. However, the evaluation showed little affect on reactivity. This result is as expected since the flux trap

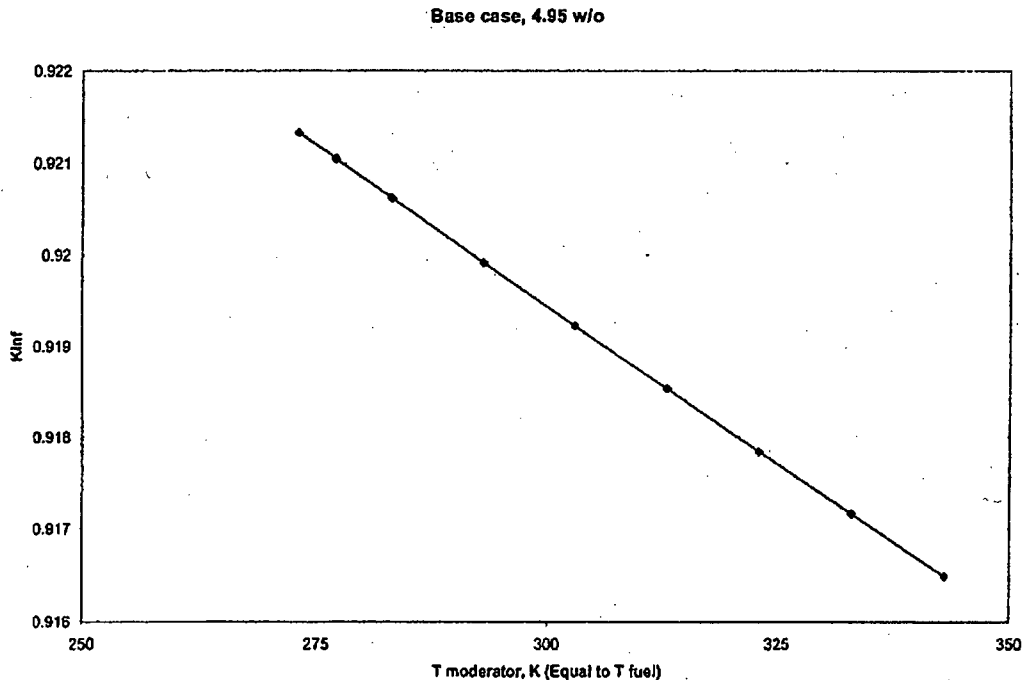
region contains ample water to moderate neutrons for absorption in the adjoining absorber material.

Past Operability

The reactivity of the most reactive fuel previously employed at Palisades, assuming the neutron absorbing material at the nominal B-10 areal density (Case B above) is 0.9059. The reactivity increases to 0.9292 when the neutron absorber B-10 areal density is reduced to 50% of nominal. This is slightly above the acceptance criteria (Case A above). Credit for 150 ppm boron reduced the reactivity to below the acceptance criteria. Therefore, past maintenance of the pool boron concentration above 150 ppm would have assured the reactivity of the rack, while loaded with the most reactive fresh bundle is below 0.95 k-effective. Since the boron concentration is worth approximately 0.010 delta-k, the rack reactivity following a postulated boron dilution event to 0 ppm would remain well below 1.0.

Temperature Coefficient

The temperature coefficient for the Region I racks in unborated water is given by the following plot which shows a decrease in reactivity with an increase in temperature.



Conclusion

This evaluation demonstrates that the reactivity reductions associated with a conservative combination of fuel burnup and enrichment more than offsets the positive reactivity effects of up to 50 % loss of the neutron absorber effectiveness. Therefore, the current configuration is less reactive than assumed in the design bases analysis so the criticality acceptance criteria of 0.95 k-effective continues to be met. This evaluation does not rely on the presence of soluble boron in the water. The high soluble boron concentration maintained in the fuel pool provides a significant additional margin. Additionally, a number of other significant conservatives are not credited providing additional margin.

Additionally, an evaluation of the most reactive fuel previously loaded employed at Palisades determined that the acceptance criteria of 0.95 k-effective would be maintained provided at least 150 ppm boron was present. The rack would remain below a k-effective of 1.0 even if a boron dilution event resulted in a boron concentration of 0 ppm.

References

- 1)- "ANO-2 Spent Fuel Pool Criticality Safety Analysis for Fuel Enrichments up to 5.0 wt. % U-235,; NEAD-SR-95/117.
- 2)- "Proceeding of a Workshop on the Use of Burnup Credit in Spent Fuel Transport Casks," S.E. Turner, SAND89-0018.

Prepared by Fred H. Smith Date 8/08/02
Reviewed by Thomas W. Allen Date 8/8/2008