Omaha Public Power District

444 South 16th Street Mall
Omaha NE 68102-2247

April 12, 2006
LIC-06-0032

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Reference:
1. Docket No. 50-285
2. Letter from Ross Ridenoure (OPPD) to Document Control Desk (NRC) dated August 11, 2005, Fort Calhoun Station Unit No. 1 - License Amendment Request to Support Use of M5 Fuel Cladding, and 10 CFR 50.46 and 10 CFR Appendix K Exemption Request (LIC-05-0089) (ML052240083)
3. Letter from Ross Ridenoure (OPPD) to Document Control Desk (NRC) dated November 8, 2005, Fort Calhoun Station Unit No. 1 – Revised License Amendment Request to Support Use of M5™ Fuel Cladding (LIC-05-0127) (ML053120421)
4. Letter from Alan Wang (NRC) to Ross Ridenoure (OPPD) dated March 2, 2006, "Fort Calhoun Station, Unit 1 – Request for Additional Information Related to the Use of M5 Fuel Cladding (TAC No. MC8096)" (NRC-06-0032) (ML060550294)
5. EMF-2103(P)(A), "Realistic Large Break LOCA Methodology," Framatome ANP, Inc.

SUBJECT: **Response to Request for Additional Information Related to the Use of M5 Fuel Cladding**

References 2 and 3 provided the Omaha Public Power District's request for a license amendment to permit the use of AREVA (Framatome ANP) M5™ advanced alloy for fuel rod cladding and structural components such as guide tubes, intermediate spacer grids, end plugs and guide thimble tubes, beginning with Cycle 24. In Reference 4, the NRC requested additional information regarding Reference 3. Attachment 1 provides the response to the request of Reference 4.

In the answer to NRC Request #2 of Attachment 1, proprietary information has been withheld as indicated by empty brackets. This information is available in Reference 5.

I declare under penalty of perjury that the foregoing is true and correct. (Executed on April 12, 2006.)

A001

If you have additional questions, or require further information, please contact Thomas R. Byrne at (402) 533-7368.

Sincerely,

Harry J. Faulhaber
Division Manager
Nuclear Engineering

HJF/TRB/trb

Attachment 1 - Response to Request for Additional Information Related to the Use of M5 Fuel Cladding

ATTACHMENT 1

Response to Request for Additional Information Related to the Use of M5 Fuel Cladding

Response to Request for Additional Information Related to the Use of M5 Fuel Cladding

NRC Request #1

To demonstrate compliance with 10 CFR 50.46 criteria, complete the tables below by providing the comparison results obtained using the base evaluation model methods with Zircaloy-4 cladding and the results obtained for an identical case using the M5 swelling and rupture model. Specifically, provide the LBLOCA and SBLOCA analysis results for calculated peak clad temperature (PCT), maximum local oxidation, and whole core hydrogen generation for both the M5 cladding (Mark-B-HTP fuel design) and the co-resident Zircaloy cladding. Also, state whether coolable geometry and long term cooling are demonstrated.

OPPD Response:

This question was discussed with the NRC in a telephone call on March 29, 2006. It was agreed that a summary of the large break LOCA (LBLOCA) results as presented below would be a sufficient response.

The results of the analysis of a large break loss of coolant accident for the Fort Calhoun Station Unit No. 1 (FCS) Cycle 24 reload using fuel assemblies with M5 cladding is presented in the report BAW-2502, "Fort Calhoun Station Realistic Large Break LOCA Summary Report." This report was provided to the NRC in Reference 1.

A summary of the results of the LBLOCA evaluation is presented below for each of the five criteria in 10 CFR 50.46:

Peak Cladding Temperature, °F	1675
Maximum Local Oxidation, %	0.82
Total Oxidation (whole core hydrogen) %	0.02
Coolable geometry	Confirmed
Long Term Cooling	Confirmed

The LBLOCA results are for the fresh fuel in the core and are conservative relative to the once-burned and beyond fuel. The LBLOCA results are more limiting (higher PCT) than the small break LOCA (SBLOCA) results.

A comparison of the results for Zircaloy-4 and M5 cladding is provided in the table below. This data is obtained from topical report EMF-2103PA for LBLOCA and from BAW-10240PA for SBLOCA. Similar results would be expected for FCS on a relative basis.

	Differences LBLOCA	SBLOCA
Peak Cladding Temperature	<10°F	<10°F
Maximum Local Oxidation	<0.1%	<0.3%
Total Oxidation (whole core hydrogen)	<0.1%	<0.1%

NRC Request #2

Does the LOCA Evaluation Model used consider both the pre-LOCA and LOCA oxidation in demonstrating compliance with 10 CFR 50.46 requirements? If not, provide justification why it does not.

OPPD Response:

The manner in which the Realistic Large Break LOCA evaluation model considers the initial cladding oxidation is described in the response to Question 28d in the NRC approved topical report EMF-2103(P)(A), "Realistic Large Break LOCA Methodology," Framatome ANP, Inc. The question and response in the NRC approved topical report are repeated below:

Question 28d: In the time-in-life study, what inside and outside initial oxidation thickness were used for the BOL analysis. What oxide thickness is used for once and twice burned fuel?

Response 28d: *The NRC reviewed and approved RODEX3A code is used to calculate an exposure dependent oxidation thickness that is transferred to S-RELAP5. S-RELAP5 uses this information for calculating cladding thermal conductivity which affects the initial stored energy results. However, a zero oxidation thickness is assumed to initialize the metal-water reaction rate calculation. Framatome ANP experience with regard to oxidation calculations has been that the oxidation calculated for a zero initial oxide thickness provides the largest oxidation thickness increase during the transient simulation. The results shown for maximum local and core-wide oxidation are those computed for the high temperature metal-water reaction. This is the same approach taken for Framatome ANP Appendix K methodologies.*

The response to this question was initially provided in response to an RAI on the topical report EMF-2328PA, PWR Small Break LOCA Evaluation Model, S-RELAP5 Based. The response provided and accepted by the NRC is shown below followed by some additional comments.

"The Framatome ANP methodology described in EMF-2328(P), PWR Small Break LOCA Evaluation Model, S-RELAP5 Based, results in a conservative calculation of peak local oxidation for comparison to the 17% oxidation criteria of 10 CFR 50.46. The methodology assumes that the pre-accident cladding oxidation is zero in order to maximize the rate and extent

of oxidation during a LOCA. This assumption results in higher peak cladding temperatures and higher peak local oxidation than assuming a non-zero pre-accident oxidation value.

Cladding oxidation from two sources is considered: (1) pre-accident or pre-transient oxidation due to corrosion at operating conditions, and (2) transient oxidation which occurs at high temperature during the LOCA. Pre-transient oxidation is determined by a fuel performance calculation and is a function of burnup. Over the burnup range that the fuel rod is at high power and can approach technical specification peaking limits, the pre-transient oxidation is small; however, at high burnups, pre-transient oxidation can become significant.

Transient oxidation is calculated as part of the LOCA analyses. By rule, this oxidation must be computed using the Baker-Just reaction rate equation. Using this equation, the calculated reaction rate decreases in direct proportion to the increase in thickness of the layer oxidized and increases exponentially with absolute temperature. Therefore, the transient oxidation is maximized by minimizing the initial oxidation layer which yields the highest reaction rate. The increased reaction rate produces higher temperatures which further increases the reaction rate, thus compounding the effect.

The reason that the assumption of zero pre-accident oxidation value results in a conservative calculation of peak cladding temperature and total peak local oxidation is that Framatome's calculations show that a non-zero pre-accident oxidation assumption reduces the transient oxidation by an amount greater than the pre-accident oxidation. Therefore, the maximum oxidation; i.e., the sum of both pre-transient and transient oxidation is greatest when zero pre-transient oxidation is assumed. These results apply for conditions where the transient oxidation is the dominant contributor to the total oxidation, which is the case for calculated PCTs in excess of 2000°F and for burnups at which peaking can approach the technical specification limits. These are the most limiting cases for both LBLOCA and SBLOCA.

Framatome also recognizes that conditions exist where the total oxidation is dominated by the pre-transient oxidation. This situation occurs when lower PCTs are calculated and at high burnups. For cases with low PCTs, the pre-accident oxidation becomes dominant because the transient oxidation is substantially reduced or effectively eliminated due to the low absolute temperature. For high burnups, the transient oxidation is reduced or effectively eliminated due to the inherent low power and associated low transient temperatures, and is further reduced by the presence of a significant initial oxide layer. For these cases, the maximum total oxidation is essentially equal to the initial pre-accident oxidation value. This oxidation value can exceed the value calculated using a zero initial pre-accident oxidation for these conditions; however, the total oxidation is precluded from approaching or exceeding the 17% value by the design limit on pre-accident oxidation. Framatome has a design limit on pre-transient oxidation of [ ] microns defined on a 95/95 basis that cannot be exceeded. This limit corresponds to [ ] of the thinnest cladding currently used by Framatome."

The above response is also applicable to the Realistic Large Break LOCA evaluation model. The key concept is that the metal water reaction rate models, Baker-Just and Cathcart-Pawel, are highly oxidation level dependent. If the transient starts with an oxidation level, the subsequent oxidation formation is significantly reduced; the larger the initial level, the more the formation of additional oxidation during the transient is reduced. The reduction of the oxidation formation during the transient then leads to a reduction in the cladding temperature since a heat source, oxidation formation, is reduced.

Reference

1. Letter from Ross Ridenoure (OPPD) to Document Control Desk (NRC) dated September 30, 2005, Fort Calhoun Station Unit No. 1 - License Amendment Request to Support Use of AREVA Realistic Large Break Loss of Coolant Accident Methodology (LIC-05-0106) (ML052770174 and ML052770176)