ENCLOSURE 6

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FRAMATOME NON-PROPRIETARY REPORT

10 Pages Follow

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Revision 0

Revised Fuel Assembly Growth Correlation for Palisades

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Nature of Changes

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		This is a new document.

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Introduction

The fuel assembly growth model for the Framatome ANP (FANP) assemblies in Palisades is based on irradiation data specific to the Palisades design. The NRC approved assembly growth model for Palisades uses a 95/95 upper and lower growth limit to a fast fluence of $8x10^{21}$ n/cm^2 and then the growth rate of the upper limit is set equal to the fuel rod cladding growth rate. This change in projected growth rate provides a conservative upper projection of the assembly growth.

As identified in the NRC review of Reference 1, the growth rate can be revised with additional irradiation data. If the resulting growth predictions vary by more than one standard deviation, the revised model has to be submitted to the NRC for review. This document provides additional irradiation data obtained on the Palisades fuel and provides the revised growth model for NRC review. The model retains the same form as the previously approved model; a lower growth rate that transitions to the high fuel rod growth rate at a specific fluence. The Palisades irradiation data support using a fast fluence of [c,d]n/cm^2 for the change in rate instead of the previous value of $8x10^{21}$ n/cm^2. This change in the rate transition fluence results in a difference in the projected end of life assembly growth of greater than one standard deviation and therefore, should be submitted to the NRC for review.

Summary

FANP has developed a new Palisades-specific fuel assembly axial growth correlation (Figure 1) based on post irradiation examination data that supports extending the transition from the recrystallized Zircaloy characteristic for guide bars to the cold worked stress relieved (CWSR) Zircaloy characteristic for fuel rods to a fast fluence of [c,d]n/cm^2. The form of the previously approved correlation is maintained along with the use of 95/95 limits for the upper and lower assembly growth.

Current Assembly Irradiation Growth Model Description

The assembly irradiation growth models are described in the correspondence supporting the NRC approval of the PWR generic mechanical design criteria (Reference 1). The form of the CE 15x15 model is two lines, intersecting at a fast fluence (>1 MeV) of $8x10^{21}$ n/cm^2. A growth model with a higher growth rate at higher fluences was used because some historical data indicated that the growth rate of recrystallized Zircaloy may accelerate at high fluence.

The lower curve is a correlation based on assembly irradiation growth data. A linear correlation of the growth as a function of the fast fluence was determined from the data for different assembly types. A conservative, upper prediction (one-sided 95% upper confidence limit) of the growth curve is established. This line provides the growth prediction for fast fluences of less than or equal to $8x10^{21}$ n/cm^2.

The predicted growth rate above $8x10^{21}$ n/cm^2 is established by the assembly growth at $8x10^{21}$ n/cm^2 plus the growth projected by a second line with a slope of the fuel rod cladding. The fuel rod is fabricated with CWSR material that grows at a faster rate than the fully recrystallized guide bar material. The increase in growth rate above $8x10^{21}$ n/cm^2 is conservatively assumed to reach the growth rate of CWSR material.

Updated Fuel Assembly Growth Correlation

The proposed assembly growth correlation was developed using recent, additional measured axial growth data from Palisades' fuel assemblies. The more recent data at higher burnup demonstrates that accelerated growth does not occur at up to 52 GWD/MTU (Fast Fluence of [c,d]n/cm^2). This allows the assumed accelerated growth to begin at 52 GWD/MTU. The methodology used calculates an upper and lower bound growth at a 95/95-confidence level, as described in Reference 1.

As identified by the NRC in the SER for Reference 1, if changes to the growth model from additional data results in changing the upper or lower bounds of the base axial growth model by more than one standard deviation, the new model should be submitted to the NRC for review.

FANP has performed a significant number of post irradiation examinations on Palisades fuel assemblies. The fuel assembly growth measurements taken during these exams are summarized in Table 1. FANP has developed a new Palisades specific axial growth correlation based on the data reported in Table 1. This new growth correlation does not include the EOC17 data listed in Table 1. The EOC17 data provide an over-check of the growth correlation. The fast fluence for the EOC17 data is calculated using the same equation that was used to calculate the EOC15 and EOC16 fast fluence. The EOC17 results are included in Figure 1.

Prediction interval methodology is used to determine the updated growth correlation consistent with the methodology used in Reference 1. Using the prediction intervals methodology, a $(1 - \alpha)100\%$ upper prediction limit for fast fluence $X = x_0$ is as follows:

$$\hat{Y}+t_{\alpha,n-2}(s)\sqrt{1+\frac{1}{n}+\frac{(x_0-\bar{x})^2}{SS_x}}$$

where

$\hat{Y}$ = assembly growth
α = 5% significance level
n = number of observations = 35
$t_{\alpha, n-2}$ = 1.6928
s = square root of the mean square residual from the regression output table
s = $(0.000771222)^{1/2}$ = 0.0278
x_0 = a particular fast fluence
$\bar{X}$ = mean fast fluence

SSx = sum of squares of fast fluence = $\sum_{1}^{35} (x-\bar{x})^2$ = 130.92

Using the upper prediction limit equation, the upper limits of growth corresponding to the various fast fluence values were calculated. The minimum tolerance is used to establish the upper and the lower prediction bound equations. The upper bound equation is established up to the highest fast fluence supported by the data in Table 1 ([c,d]).

Y_{upper} = [c,d] upper bound

The upper bound of the correlation for fast fluences above [c,d]n/cm^2 is established by imposing the CWSR growth rate as:

Y_{upper} = [c,d] upper bound

A lower bound line established in which tolerance bound was subtracted from the nominal growth correlation:

Y_{lower} = [c,d] lower bound

Following the methodology in Reference 1, the lower bound line is extended to a fast fluence of [c,d] n/cm^2.

Figure 1 shows the revised nominal growth correlation, the revised upper and lower bounds and the Palisades specific growth data reported in Table 1.

References

1. EMF-92-116(P)(A) Revision 0, Generic Mechanical Design Criteria for PWR Fuel Designs, February 1999.

Table 1: Palisades Growth Data

[

c,d

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Figure 1: Palisades Assembly Growth vs. Fast Fluence

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c,d

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