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July 17, 1990

2CAN079008

U. S. Nuclear Regulatory Commission
Document Control Desk
Mail Station P1-137
Washington, DC 20555

Subject: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Response to NRC Questions on
Extended Burnup Report CEN-386-P

Gentlemen:

As a followup to a telephone conference of June 26, 1990, between members of the NRC staff responsible for the review of the subject report and members of my staff and representatives of ABB Combustion Engineering, the attached information is provided in response to questions related to statistical treatment of the elastic strain in the fuel cladding at end-of-life and of the measured axial fuel rod pellet-to-pellet gaps.

Should you have any further questions on the report, please contact me.

Very truly yours,

James J. Fisicaro

James J. Fisicaro
Manager, Licensing

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Attachment
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ATTACHMENT

Request:

Provide clarification involving a statistical treatment of the expected amount of elastic strain in fuel cladding at end-of-life (EOL), based on available irradiation data.

Response:

Total uniform strain at EOL is the sum of the elastic strain plus uniform plastic strain. Uniform plastic strain was measured on Fort Calhoun fuel rods as 0.03-0.11%, at a burnup of 55-63 MWd/kgM (Ref. 1).

Elastic strain at EOL was determined by the ratio of irradiated yield strength to the irradiated Young's modulus. The yield strength range at EOL for fuel cladding was estimated by using the average and 95/95 confidence limits of the irradiated yield strength data from the Fort Calhoun program (Ref. 1). These values are 120.5 ksi average with 106.7 and 134.2 ksi 95/95 confidence limits. The irradiated Young's modulus at EOL was calculated using the MATPRO model, accounting for cold-working and neutron fluence, and applying 95% confidence limits. These values are 10.5×10^6 psi average with 8.64 and 12.36×10^6 psi 95% confidence limits at 60 MWd/kgM.

The average and 95/95 confidence limits of the uniform total strain were estimated by dividing the calculated average and range of the irradiated yield strength by the calculated average and range of the Young's modulus, and adding the measured uniform plastic strain average and range. The resulting calculated band for uniform total strain at 60 MWd/kgM is 1.22% average strain and 95/95 confidence limits of 0.89 and 1.66% strain. Assuming a normal distribution for this band gives only a 9% chance that the total uniform strain will drop below 1% at EOL.

The lower limit of 0.89% total strain was generated by dividing the lower confidence limit of the yield strength by the upper confidence limit of the Young's modulus and adding the minimum measured uniform plastic strain of 0.03%. Yield strength and Young's modulus both increase with irradiation, so this combination of the lower bound of the yield strength with the upper bound of the Young's modulus is a very unlikely worst-case scenario from a technical standpoint.

Reference

1. A. M. Garde, "Hot Cell Examination of Extended Burnup Fuel from Fort Calhoun", DOE/ET/34030-11, CEND-427, Combustion Engineering Inc., September 1986.

Request:

Provide for clarification involving a statistical treatment of measured axial fuel rod pellet-to-pellet gaps.

Response:

Axial pellet-to-pellet gaps were measured in San Onofre 2 (16x16) fuel. Axial gap sizes were obtained using a gamma scan technique. Seventeen fuel rods were found to contain a total of 30 axial gaps of varying sizes. The maximum gap size was 0.9 inches in the "cold" condition. Cold gap sizes were reduced to obtain hot axial gap sizes using the axial thermal expansion of the fuel stack length below the gap. The maximum "cold" gap reduces to a hot gap of 0.3 inches and is the maximum hot gap. Because most of the gaps are small the average hot gap is less than 0.04 inches. Although the data base is limited, one can assume that the gap distribution is normal and statistically compute the size of a gap representing the maximum expected at a 95% probability and 95% confidence level. Based on this limited data set the maximum gap at 95% probability and 95% confidence level is 0.19 inches. Thus, the maximum hot gap of 0.3 inches is greater than one would expect at a 95% probability level. Furthermore, the clad collapse analysis was based on an axial gap larger than 0.3 inches. Therefore, the clad collapse analysis is significantly conservative relative to an expected gap at the 95% probability level.