GENERAL ELECTRIC

NUCLEAR ENERGY

PROJECTS DIVISION

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RLG-087-79

June 29, 1979

U. S. Nuclear Regulatory Commission
Division of Operating Reactors
Office of Nuclear Reactor Regulation
Washington, D. C. 20555

Attention: Mr. Paul S. Check
Division of Operating Reactors
Office of Nuclear Reactor Regulation

Gentlemen:

SUBJECT: RESPONSES TO NRC ADDITIONAL QUESTIONS ON CONTROL BLADE LIFE (B_4C LOSS)

Reference: F. D. Coffman, Jr. to A. M. Ervin, telecopy of 6/15/79.

Attached are the responses to the NRC questions to the referenced communication.

If you have any further questions or comments on this subject, please contact R. O. Brugge of my staff on (408) 925-3360.

Respectfully,

R. L. Gridley, Manager
Operating Plant Licensing
Safety & Licensing Operating

RLG:sj/389

Attachment

cc: Mr. F. D. Coffman, Jr.
DOR/NRR

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RESPONSES TO NRC REQUEST FOR
ADDITIONAL INFORMATION ON
CONTROL BLADE LIFE (B_4C LOSS)

Question 1

Please provide the data used to develop the correlation between B_4C loss and B^{10} depletion and describe more completely the methods used to measure the B_4C loss and calculate the B^{10} depletion; include any additional data developed since your letter was written.

Answer 1

The data used to develop the correlation between B_4C loss and B^{10} depletion was provided in the presentation given by Dr. D. L. Fischer of General Electric Company on March 22, 1979. NRC personnel attending included Paul S. Check and F.D. Coffman. Figure 1 is a copy of data given in the presentation. The data shown is the average depletion obtained from hot cell examinations of control blades at 100% and 80% of the previously defined control blade lifetime.

The amount of missing B_4C from individual tubes was determined by neutron radiography performed in hot cells. Conservatively included in the total amount of missing B_4C were any grey zones where the B_4C was not missing but in some stage of decomposition. Also, in determining the amount of missing B_4C, the B_4C tubes were assumed to be perfectly full with no settling. The amount of missing B_4C is calculated from the elevation difference between the B_4C column indicated in the as-built drawing and the level of the solid black B_4C as observed in the radiographs of the absorber tubes.

The local B^{10} depletion was determined experimentally by B_{10}/B_{11} assay analyses, and analytically by control blade burn up profiles which were calculated using Monte Carlo techniques for one control blade with no B_4C loss.[1] Assay analyses were performed in a hot cell using mass spectrometry. The assay analyses were performed on both sets of rods shown in Figure 1.

Question 2

Explain how the above data supports the conclusion that there will be no local loss of B_4C until a B^{10} depletion of 50% has been achieved.

Answer 2

The B_4C loss was concentrated in the high burn up region of the control blade and the shape of the distribution curve of the missing B_4C was identical to the anticipated control blade burn up profile

[1] C. M. Kang, E. C. Hansen, Endf/B-IV Benchmark Analyses with Full Three-Dimensional Monte Carlo Models, ANS Transactions, Vol. 27, Pages 891-892, 1977

(Figure 1). By superimposing the analytically derived control blade burn up profiles on the B_4C loss data, it was determined that the 50% local burn up profile was the best fit to the B_4C loss profile. B^{10}/B^{11} assay analyses performed on one of the control blades with a crack but no B_4C loss at 100% of the previously defined control blade life confirmed that the peak burn up in the rod was 50%. For the absorber rods at 80% of previous life the assay samples were taken immediately below the point where the absence of B_4C was observed. The local burn up at this elevation was slightly higher than 50%.

Previous examinations performed by GE at VNC also substantiated the correlation of a 50% local burn up as the onset of leaching. In 1968, GE placed four (4) absorber rods in fuel assemblies exposed in the Dresden 1 reactor in order to achieve accelerated burn up. After four cycles of operation, only two tubes remained in the reactor (the other two had already been returned to a hot cell) and both were visually inspected and found to be sound. At the end of the fifth cycle the rods were inspected and they were observed to have large cracks and most of the B_4C was missing. Calculated burn up of these two rods was in excess of 50% along their length. Therefore, by our current correlation, this clad failure and B_4C loss would have been predicted. At the time these observations were made the cause of the failure was thought to be excessive internal pressure due to helium gas build up. The average burn up achieved had exceeded the mechanical lifetime based on internal gas pressure as defined by models used at that time.

In 1974, five tubes from a Dresden 1 control blade at 80% of previously defined control blade life were examined. One of the absorber rods had a through wall crack with no apparent B_4C loss and another absorber rod had incipient cracks. The absorber rod with the through wall crack had a local burn up of 52% and the rod with incipient cracks had a burn up of 46%. At that time the failure of the rod with the through wall crack was thought to be a random flaw; however, to verify this conclusion, GE initiated a program for further evaluation of control blade performance.

Recent absorber rod examinations show cracks extending below the bottom elevation of the areas of B_4C loss, and tubes with no B_4C loss were observed to have through wall cracks. In both failure modes, no B_4C was observed to have leached out of absorber tubes with less than 50% burn up.

All the cases cited substantiate 50% local B^{10} burn up as the onset of B_4C loss. By using this correlation, the amount of B_4C loss was predicted for a Big Rock Point control blade which was beyond the previously defined end of control blade life. The predicted B_4C loss was equivalent to the measured loss as determined by neutron radiography performed at VNC.

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Question 3

Explain how the above data supports the conclusion that blades with less than 80% of the previously defined blade lifetime will have insignificant B_4C missing.

Answer 3

The presence of B_4C as a function of B^{10} depletion shown in Figure 1 illustrates the type of B_4C loss which would be anticipated for a control blade at 80% of the previous design lifetime. This loss is based on neutron radiographs of tubes removed from a control blade at 80% of life. The amount of B_4C missing is small and has negligible impact on control rod reactivity worth and on core physics calculations impacted by control rod worth such as shutdown margin and scram reactivity. The B_4C is assumed to be gone at 50% local B^{10} depletion and no credit is taken for the fact that the missing B_4C had been depleted (i.e., the change in control rod worth is conservatively evaluated against fresh B_4C or a new control rod).

Question 4

Explain how you have determined that the effect of B_4C loss on MCPR can be bound for all BWRs by assuming that 26% of the blades have B^{10} depletion distributions representative of the previously defined end-of-life blade.

Answer 4

The MCPR effect was evaluated for operating BWR plants for which General Electric Company is currently providing reload fuel and fuel management services. For these plants, the limiting case was a plant which would have had 26% of its blades in excess of the previously defined end of life blade. Therefore, the evaluation was performed on this plant.

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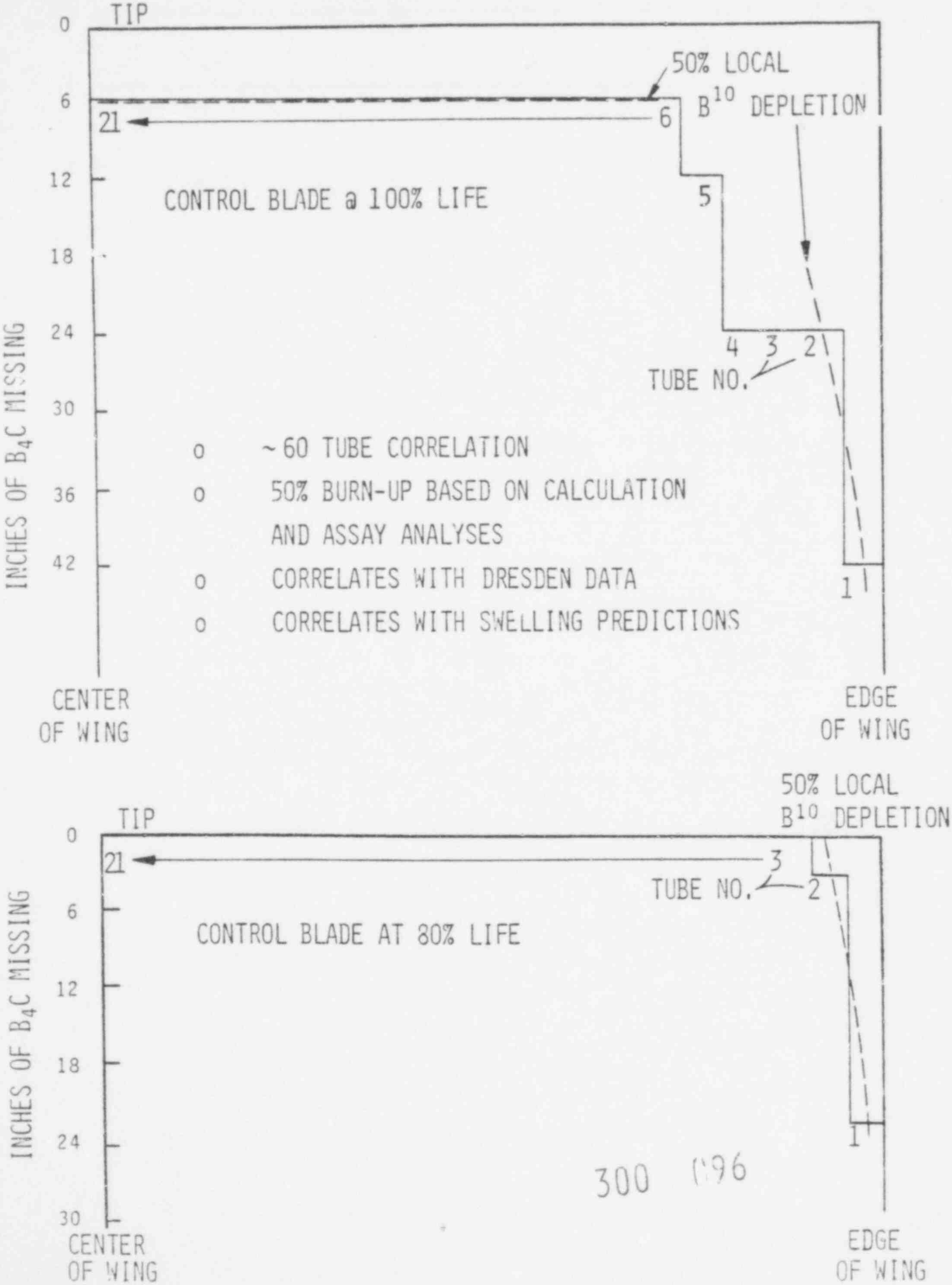
FIGURE 1

LOSS OF B_4C VS. B^{10} DEPLETION



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