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TITLE

ESTIMATION OF MINIMUM TUBE LIFE IN C REACTOR
AS DETERMINED BY GRAPHITE DISTORTION

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ESTIMATION OF MINIMUM TUBE LIFE IN
C REACTOR AS DETERMINED BY GRAPHITE DISTORTION

by

R. W. Benoliel

April 28, 1960

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ESTIMATION OF MINIMUM TUBE LIFE IN
C REACTOR AS DETERMINED BY GRAPHITE DISTORTION

INTRODUCTION

In consideration of the intended retubing of C Reactor with zirconium process tubes, the question has been raised as to whether certain tube channels, presumably some in the top part of the reactor, distort at such a rate due to contraction of the graphite stack that it would not be economic to put zirconium tubes in those channels. That is, it is desirable to know whether inability to charge fuel elements into such tubes might develop in so few years and require tube removal and channel straightening that it would not be economic to put the more costly and intrinsically longer-lived zirconium tubes into certain channels.

CONCLUSIONS

The future course of distortion of the C Reactor stack has been estimated based on the extent of distortion to date. It is concluded that no difficulty should be encountered in charging regular eight inch fuel elements into any tubes including top center tubes of C Reactor for at least 10 to 15 years and probably for a significantly longer time even if the reactor power level is increased 50 percent.

DISCUSSION

The manometer traverse of the top center tube 4674 at C Reactor on 3/5/60 indicates a 6 mil arc-to-chord distance between an 8.87" chord (the nominal length of an 8 inch fuel element) and the curvature of the process tube both at the inlet hump and at the center depression. The clearance between an unwarped element and the process tube in a straight section with full height ribs is a nominal 60 mils. It has taken 4 1/2 equivalent 1959 power level years for this amount of distortion to develop in the top tubes in C Reactor.

At the present power level therefore, it would take a calculated 40 1/2 years to develop 60 mils arc-to-chord distance in top center tubes which would be limiting for passage of an unwarped 8 inch fuel element in a ribbed tube. Under the

$$\frac{(60-6) \text{ mils}}{6 \text{ mils}} \times 4 \frac{1}{2} \text{ yrs.} = 40 \frac{1}{2} \text{ yrs.}$$

same conditions but for 20 mils of warp in the fuel element the time would be 18 years.

$$\frac{(60-6-20) \text{ mils}}{6 \text{ mils}} \times 4 \frac{1}{2} \text{ yrs.} = 18 \text{ yrs.}$$

For possible future operation at 150 percent of present power level, with ribless tubes and 8 inch self-supported fuel elements with 10 mils of warp, the limiting time is calculated as 35 years. This calculation assumes 1) linear dependence of graphite contraction rate on temperature in °C and linear relation of temperature in °C to power level, 2) that for self-supported fuel elements in ribless tubes of either present tube diameter or larger, the fuel element diameter and the height, length and location of supports are such that the limiting arc-to-chord distance is twice the 60 mils limiting in ribbed tubes, and 3) that the

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warp of self-supported fuel elements will be only half that for fuel elements in ribbed tubes.

$$\frac{(2 \times 60-6-10) \text{ mils}}{6 \text{ mils}} \times 4 \frac{1}{2} \text{ yrs} \times \left(\frac{1}{1.5}\right)^2 = 35 \text{ yrs.}$$

In the attached figure the arc-to-chord distance in the top center process tube at both the center depression and the inlet hump at C Reactor are plotted against cumulative power generated in the reactor. To illustrate the marked difference from the severe curvature of the process tube at the inlet hump at the old reactors, data for the top center tube of F Reactor are included on the plot.

The extrapolations to the time periods cited above are quite considerable and the lengths of times calculated cannot be considered very accurate. If a factor of ignorance of 2 is applied, one still has a period of nearly 10 years for continued present operation and about 15 years for possible future operation with self-supported fuel elements in ribless tubes before limiting curvatures are developed in top tubes.

No allowance has been included in the calculations for the lengthening of the time periods which could be obtained through use of shorter fuel elements. It might be observed, moreover, that the calculations indicate that fuel elements even longer than 8.87 inches could be charged for many years even in top tubes in the reactor.

It should be remarked that it seems most likely that even in the highest flux zones of C Reactor, contraction of the graphite will continue throughout all, or at least almost all, of the entire operating life of the reactor of, say, 20 additional years. That is, it is estimated that "saturation" of contraction damage in the graphite in even the center of this reactor will not occur at least until nearly 20 years from now even if the reactor is operated at 150 percent of the present power level. The estimates of time presented in this memorandum have assumed a continued linear rate with exposure and a linear dependence of this rate of the temperature expressed in $^{\circ}\text{C}$. In turn, the temperature in $^{\circ}\text{C}$ has been assumed to be proportional to the power level. It is possible, moreover, that the rate of contraction per unit of power generated, normalized for any temperature dependence of the rate, will decrease with continued exposure of the graphite rather than continue at the constant rate which has been evidenced to date.

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COMPARISON OF DEVELOPMENT OF CURVATURE
IN TOP CENTER PROCESS TUBES AT C AND F REACTORS

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