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PRODUCTION TEST IP-312-A; INCREASE OF GRAPHITE TEMPERATURE
LIMIT AT 105 KE AND KW

by

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PRODUCTION TEST IP-312-A; INCREASE OF GRAPHITE TEMPERATURE
LIMIT AT 105 KE AND KW

OBJECTIVE

This production test is designed to demonstrate that the K Reactors can be operated with a higher graphite temperature limit than stipulated in present standards without a significant increase in the rate of either burnout or contraction of the graphite moderator stack.

SCOPE

It is intended that the increase in allowable maximum graphite temperature will be utilized to permit operation with slightly higher reactor power levels with substantially the same enrichment level of the total uranium fuel charge as is currently in practice at the K Reactors.

(A possible supplement to this production test or a separate, coordinated production test may be proposed to test the possible control advantages obtainable through addition to the reactor gas atmosphere of nitrogen rather than carbon dioxide.)

BASIS AND JUSTIFICATION

During three to nine months of the year, power levels at the K Reactors have frequently been limited by the graphite temperature limits stipulated in Process Standard, C-040.⁽¹⁾ It is estimated that the reactors could be operated at levels about 100 MW higher than in present practice during that portion of the year if the maximum graphite temperature were permitted to exceed the present allowable limits by some amount not greater than 50°C.

The primary consideration in setting a graphite temperature limit is the effect of temperature on reactor life. The effect is of consequence in two respects: 1) the effect of temperature on the rate of contraction of graphite per unit of power generated and 2) the effect of temperature on the rate of burnout of the graphite moderator stack per unit of time. The present temperature limits were set with a considerable degree of conservatism with regard to the above effects because of 1) lack of reactor operating experience under the conditions, and because of 2) limited correlations and projections possible from laboratory experimental data.⁽²⁻⁴⁾

It was contemplated at the time of setting the present graphite temperature limits that continued operation of the reactors would indicate stepwise increases in the limits to be desirable and allowable.

(It is pertinent to point out that the major program for expansion of the old reactors, currently being scoped, calls for very substantial increases in power levels which would necessarily increase both the average and maximum graphite temperature over present levels.)

Effect of Temperature Increase on Contraction

At the present time as shown in Figure 1, the top centers of the K Reactors graphite stacks have dropped to about two inches below original layup. At

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FIGURE I - CONTRACTION OF GRAPHITE MODERATOR STACK OF KE AND KW REACTORS

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present power levels the rate of drop for both reactors is about 0.6 inches per year. Or, one can say, the rate of drop is about 0.64 inches per 10^6 MWD generated in the reactor.

There is some evidence from laboratory data that contraction rate might be a linear function of temperature but also there are other data which indicate that contraction is relatively insensitive to temperature from 500-1000°C.⁽⁵⁾

The dependence of contraction rate on temperature cannot be determined from the reactor data; however, an assumption of a linear dependence is not inconsistent with measurements made on the reactor stacks. For example, plots of the elevation of the top center of C, DR, and H Reactors with cumulative power generation all show a slight (and irregular) downward curve. Graphite temperatures have increased with time (and cumulative power generation) at these reactors. A positive effect of temperature on graphite contraction rate in these reactors would produce a downward curve of such data. (A similar observation is not possible from the data for B, D, and F Reactors because of the initial period of substantial expansion of the graphite at these reactors. No curving is legitimately evident in the data from the K Reactors because of the very few data points. Furthermore K Reactors have not been operated for substantial periods of time with significantly different graphite temperatures.)

Increasing the maximum allowable graphite temperature perhaps 50°C would probably result in an increase of considerably less than 50°C in the time-weighted average graphite temperature in the central zone of the moderator stack. If this increase were to be, say, 25°C, and it would likely not be this large, the rate of graphite contraction or rate of depression of the top center of the K moderator stacks assuming a linear temperature dependence would be increased about 5 percent - from 0.60 inches per year to 0.63 inches per year at present power levels. Such an increase could not be read out of measurements on the reactor stack.

Effect of Temperature Increase on Burnout

Burnout of the graphite in the K Reactors has been monitored through determining the weight loss of small test pieces approximately 0.4 inches in diameter and 4 inches long of the same kind of graphite of which the stack is constructed. These samples are placed in graphite boats in one untubed process tube channel in each reactor. As indicated in Figure 2 below, these have shown burnout at rates about half of the 2 percent/1000 operating days deemed allowable.

Distance from Front Face of Graphite in Feet
FIGURE 2 - RATE OF BURNOUT OF GRAPHITE IN K REACTORS

Correlations of the rate data for the monitoring samples in the K Reactors and the other Hanford reactors with the best measurements and estimates of the temperature of the graphite show that these rates are somewhat higher than expected for the reaction with even an atmosphere of 100 percent carbon dioxide(3,6) as shown in Figure 3 attached. This permits the contention that the burnout actually occurring is due to reaction with oxygen of air admitted to the reactor atmosphere. The specific rate of reaction of graphite with oxygen is much more rapid than that with carbon dioxide or water vapor. It would be expected, therefore, that with the graphite temperature limit increased about 50°C to correspond with the position of the line shown in Figure 3 for 100 percent carbon dioxide, there would be little if any measurable increase in the rate of burnout of the graphite. (The lines in Figure 3 for rate of burnout with 10 percent and 1 percent carbon dioxide are based on the reasonable assumption that the rate of oxidation of graphite with carbon dioxide is proportional to the concentration of carbon dioxide, i.e., a first order reaction.)

Stipulation of Increased Graphite Temperature Limit for this Test

The data of Figure 3 for a burnout rate of 2 percent per 1000 operating days are plotted on the attached Figure 4 which presents also the present graphite temperature limit curve of Process Standard C-040. It is proposed that this new line (with the arbitrary shape from about 95 to 100 percent helium, the theoretical line if burnout rate is considered limiting would approach 100 percent helium as an asymptote) be used as the graphite temperature to be subject of investigation under this production test.

TEST DETAILS

Operating Conditions: The attached Figure 4 shows the graphite temperature limits as currently defined in Process Standard C-040 and the new upper limit authorized by this test as functions of helium concentration. (It is contemplated that helium concentration will be determined by Orsat analysis with removal of carbon dioxide. Process Standard B-010 requirements for oxygen and nitrogen concentrations are not altered by this production test.)

Graphite stringer temperatures in the 0.130" coring zone can exceed the limit defined in Figure 4 by 50°C. (Operating experience at the K Reactors indicates relatively higher temperatures in this limited region on the far side than in neighboring 0.060" coring zone toward the center of the reactor. A possible moderately higher burnout rate in the 0.130" zone would not be harmful to the integrity of the reactor stack.)

Monitoring: Burnout samples in the same process channels used to date (3066-KE; 1880-KW) shall be monitored after any interval of time three months or longer during which interval there has been a significant amount of operation with graphite temperatures above the present standard limit.

Manometer traverses of the Y-2 holes shall be made as called for in Process Standard G-010.

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FIGURE 3 - RATE OF OXIDATION OF GRAPHITE BY CARBON DIOXIDE

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FIGURE 4 - GRAPHITE TEMPERATURE LIMIT FOR TEST
AT KE AND KW REACTORS

* Add 50°C to maximum limit for graphite within one lattice unit of:

- (1) Uncooled process tube channel
- (2) Enrichment columns when helium percentage is above 95%

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Time and Termination: This test will continue for two years from the date of approval except that the test may be terminated at any earlier date by Research and Engineering if in their opinion conditions of the test indicate continuation would excessively shorten reactor life. (The necessity for early termination for this reason is considered exceedingly unlikely.)

Cost: No extra costs are associated with the conduct of this test (except those for the more frequent monitoring of graphite distortion and burnout samples).

Priority: Additional reactor down time and front and rear elevator time are authorized, if needed, for traversing the Y-2 holes and removing and charging burnout monitoring samples if this monitoring has not been conducted after approval of this test within a month of the intervals indicated above.

Hazards: There is no significant hazard associated with the authorized increase in graphite temperature limit as provided herein.

RESPONSIBILITY

Process and Reactor Development shall be responsible for 1) analyzing the traverse and burnout data, 2) evaluating the effects of the higher graphite temperature limit on reactor life, 3) preparing any desirable supplements to this test and 4) issuing interim and final reports on this test.

KF Processing and KW Processing shall be responsible for scheduling the manometer traversing (with Irradiation Testing Operation) and the burnout sample monitoring (to be done by Irradiation Testing Operation and by Nonmetallic Materials Development Operation, Hanford Laboratories) as called for in this test.

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