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GRAPHITE POWER COEFFICIENT DETERMINATION

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June 16, 1961

SUPPLEMENT A: PT IP-105-C
GRAPHITE POWER COEFFICIENT DETERMINATION

OBJECTIVE

The objective of this supplement to PT IP-105-C/1/ is to review the basis, justification and procedure so that this production test may be used permitting a determination of minimum downtime, when advisable for improving moderator coefficient data as a function of exposure.

/1/ HW-51799, PT IP-105-C Graphite Power Coefficient Determination, GR Parkos, 8-30-57

BASIS AND JUSTIFICATION

Plutonium buildup causes a positive change in the graphite coefficient of reactivity; therefore, the observed operating coefficient increases with increasing pile residual. The variation of the graphite power coefficient (C_g) with the exposure of the uranium load is ordinarily determined by plotting the apparent graphite coefficient, obtained from start-up reactivity data, versus the flux squared weighted residual exposure status of the reactor at shutdown. Minimum outage data are considered to be the most reliable since the data are not complicated by assumptions concerning the c-mk values of temporary poison columns and horizontal control rods; rods and temporary poison loadings also affect the pile flux distribution, thereby further complicating the data.

The range of residual exposure of the metal in a reactor is set by the exposure of the uranium discharges taken and the outage frequency. Minimum outage information is required at intervals along the entire exposure range before a reasonably accurate estimate of the variation of the graphite coefficient with exposure throughout this range can be made. Any time the goal exposure of the uranium discharges is changed, the range of exposure over which this variation must be estimated changes.

If a reactor operates with a constant goal exposure for discharges, a dilemma necessarily arises. At the low end of the exposure range, minimum outages are more common because there is little metal ready to discharge when the reactor is shut down, so operation is resumed as soon as possible. If a shutdown occurs when the exposure is near the high end of the exposure range, a large metal discharge is almost certain. These large discharges usually require a good deal of outage time, and this makes it necessary to charge temporary poison before startup. The minimum outage information obtained is usually distributed over the exposure range as follows:

MODERATOR COEFFICIENT DATA AVAILABILITY

<u>EXPOSURE</u>	<u>MINIMUM OUTAGES</u>
Low end of range	Many
Middle of range	Few
High end of range	Exceedingly rare

Because of the minimum outage distribution, it is not possible to accurately estimate the dependence of C_g on $\bar{E}$ from startup information until sufficient data has accumulated for one particular set of operating conditions. Power and fuel exposure range increases, fuel element redesign, flow increases, control rod replacement and reactor gas composition changes each may require refinement or complete revaluation of C_g and other reactivity variables. Since such changes have occurred frequently in the past and will probably continue to occur in the future, a means should be available whereby adequate empirical data can be collected more readily.

Knowledge of the variation of C_g with reactor exposure is very important for the following reasons:

1. Prediction accuracy is quite dependent upon a knowledge of C_g . Reactor safety considerations require accurate predictions of pile reactivity, or a cautious approach to critical.

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2. Production losses can result from inaccurate knowledge of the pile reactivity status. These losses can be the result of the following:
 - a. Increased downtime resulting from the required cautious approach to critical.
 - b. Increased probability that a scram will result in a minimum outage because of a poor knowledge of the scram transient.

Special reactor loadings may cause changes, not only the graphite temperature coefficient but also in other reactivity parameters. It is, therefore, even more necessary that the pile reactivity be determined. Since the minimum outage provides data with a minimum of variables this production test will aid in determining pile reactivity and the adequacy of reactor safety calculations.

This test will permit obtaining "forced" minimum outage data during any shutdown. These data will be used to determine the dependence of C_g on E , and should eliminate or greatly alleviate the difficulties cited above.

The proposed technique consists of pulling the HCR's and VSR's out of the pile with normal shutdown water flow, and maintaining this status until the continuing xenon decay produces a slightly super-critical condition. The flux monitor system trip settings must be such that the reactor power level cannot exceed 1 MW without initiating a scram. Low level neutron monitoring equipment must be operating, and must be observed continuously throughout the entire test.

The procedure listed below would be initiated by mutual agreement between the Process Manager and the Pile Physicist at the affected reactor.

1. At the time chosen for the scheduled outage the reactor will be shut down over a ten minute period, and a scram-transient test will be performed. (Elimination of the scram transient test will not materially affect the results. The rest of the test may be performed if the scram transient test is eliminated.)
2. Normal shutdown work will proceed throughout the entire test.
3. Shielding blocks will be placed over all empty channels before the VSR's and HCR's are withdrawn after completion of the scram transient test.
4. The Beckman trip settings will be such that the reactor power level cannot exceed 1 MW without scrambling the reactor.
5. The Pile Physicist will supply a critical prediction, be present before rod pulls begin, and remain until the test is completed.
6. The sub-critical monitoring equipment will be in service at all times.
7. The Panellit system will be bypassed and total pile water flow will be maintained at or above shutdown flow as specified in Process Standard A-030.
8. The LP and LLP trips will be bypassed.
9. The Ball 3X system will be unlocked at all times during the test when the VSR's are out of the reactor. Process water pressure will be constantly monitored. The Ball 3X system will be manually tripped in the event of process water loss and subsequent failure of the VSR's to drop when manually scrambled.

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10. At about four hours before estimated minimum downtime all VSR's and HCR's (or as much of the HCR system as is permitted by the enrichment status of the reactor) will be withdrawn from the pile. The rate of rod withdrawal will be as specified for normal cold start-ups. The withdrawals must be completed at least three hours before predicted critical.
11. The rod configuration attained in Step 10 will be maintained until a rising period is noted, and sufficient data are obtained; however, power levels shall not exceed 1 MW. The HCR's and VSR's will then be re-inserted.
12. The procedure listed above will be repeated for the rod configuration which existed just prior to shutdown if it is planned that the outage will continue for sufficient time for the pile to go critical with this configuration. After sufficient data has been obtained the HCR's and VSR's will be fully inserted; further withdrawals will be governed by normal start-up procedures.

OPERATIONAL DATA REQUIRED

Charge-discharge operations may proceed during the test but the charging of temporary poison should be left until completion of the test. Since discharging uranium affects the reactivity of the pile, the status of the discharging must be known at the time(s) critical is observed. Factor, and PF^2 data for the tubes actually discharged before critical is observed will be obtained from production scheduling operation.

Data concerning the time(s) critical occurred, and subsequent period data will be collected by the Pile Physicist and Processing personnel.

REACTOR SAFETY

The only non-routine technique involved which affects pile safety is withdrawing the rods and allowing xenon decay to produce a slightly super-critical condition (very slow period) with shutdown flow. The HCR's and VSR's will be pulled sufficiently before predicted critical time to insure that the reactor will be sub-critical when the rod pulls are completed. Sub-critical neutron monitoring instruments will be observed continuously from the beginning of the rod pulls until the test is completed. The provisions of the test specify that the Beckman trip settings will be such that the pile power level can never exceed 1 MW without initiating a scram. Since negligible heat generation results at these power levels, normal shutdown flow insures adequate cooling; thus, bypassing the Panellit system and maintaining normal shutdown flow does not jeopardize pile safety. Since the approach to critical depends solely on xenon decay, it is not possible to get a "fast" period provided that shutdown flow is maintained.

PERSONNEL SAFETY

While the reactor is sub-critical, radiation levels will not be affected by the test. Experience at H Reactor indicates that normal rear face radiation levels are limited by the background radiation at power levels up to 1 MW. Normal shutdown work may thus proceed safely provided that shielding blocks have been placed over any dry channels.

PROCESS STANDARDS

Normally VSR and HCR withdrawals are made only after full operating water pressure and flow are attained. The process standards relating to rod withdrawals assume that these

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conditions are met. Since this test will require rod withdrawal under low water pressure and flow conditions, it is not consistent with standard operating philosophy and standards relating to rod withdrawal. Conservative withdrawal procedures and sub-critical monitoring will, therefore, be used to ensure that the necessary relaxations of the process standards do not constitute a threat to reactor safety.

MANPOWER REQUIREMENTS

1 Instrument Man	about 8 hours
2 Pile Operators	about 8 hours
1 Reactor Specialist	about 8 hours
1 Pile Physicist	about 8 hours

COST

Production losses will be negligible. The scram transient test requires about the first hour of downtime whenever it is run, but this portion of the test may be eliminated during the particular outage without affecting the results of the test. Any costs for additional machine time for analysis of the particular discharge data will be covered by the Operational Physics Operation.

RESPONSIBILITY

Reactor Processing Operations will be responsible for the safety and operating continuity of the reactor.

The Pile Physicist will be responsible for assisting in carrying out the test and for analyzing the data and reporting the results.

RD Carter
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