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PRODUCTION TEST IP-394-I
USE OF PT-216 FUEL COLUMNS
FOR ROUTINE AXIAL FLUX DETERMINATION

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PRODUCTION TEST IP-394-I
USE OF PT-216 FUEL COLUMNS
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OBJECTIVE

It is the objective of this production test to authorize the use of PT IP-216-A (Quality Certification) fuel columns and supplementary numbered columns as required for obtaining routine axial flux measurements suitable for metal performance analysis.

BASIS AND JUSTIFICATION

An important variable affecting in-pile fuel element performance is the axial flux configuration. The quantitative effect of changing axial flux has been thoroughly discussed and documented⁽¹⁾. As a convenient review, Figure 1 has been abstracted from the referenced document and appended to this production test. It will be noted that with a front-to-rear centered flux distribution, a ten per cent change in peaking from a normal cosine flux distribution will affect fuel performance by a factor of two. A similar factor of two change in fuel performance from that calculated with a cosine flux distribution can be approached by flux skewing (with no peaking) if the maximum flux is obtained five slugs upstream or downstream of the center of the fuel charge. From these examples and further examination of the attached graph, it can be seen that fuel element performance is very sensitive to changes in axial flux distribution; thus it is highly desirable that routine axial flux data be obtained at all reactors to supplement the current rupture analysis effort. A metal performance improvement of a factor of two can have an affect on the optimum maximum tube power of 50 kw or more.

During the past several years, significant production losses have resulted because of insufficient axial flux data. Last winter at C reactor, an adverse change in axial flux distribution accounted for a substantial part of the high-rupture incidence that was experienced. In 1958, at H reactor, data from an intensified program of monitoring axial flux profiles suggested that an unfavorable flux distribution on the near side could have accounted for the high failure rate observed in that region of the reactor. This year, until the two recent bumper fuel element failures at D reactor were sustained, all D reactor ruptures since December, 1959 (eleven), have occurred within four to six lattice units of the near side enrichment ring. Whether a preferentially unfavorable near side axial flux distribution existed this year at D reactor has not been determined because of insufficient flux data. There are many other instances, less dramatic in nature, which lend support to the desirability to obtaining sufficient axial flux data on a routine basis. In most cases, if sufficient comparative flux had been available, poor fuel performance could have been averted or at least more quickly rectified.

(1) HW-61496, Neef, W.I., "Rupture Potential and Axial Power Distribution, August 11, 1959, (Secret).

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It should also be stressed that, even with essentially normal or expected fuel element failure rates, equally important benefits from routine axial flux data can be obtained. Significant gains in reactor power levels may be possible through a continuing program of flux configuration improvement for all reactor locations. Determination of changes in control rod positioning, natural metal charge length, E-metal column makeup and positioning, and poison usage should be based upon well defined axial flux configurations. Relatively small changes in any of the above variables can have a significant long-term effect on fuel performance.

There is a need for two types of axial-flux data. The first type is relatively instantaneous flux data which can be used to base short-term adjustment to horizontal rod configuration. Methods under investigation for obtaining this type of data include: geminol graphite stringer temperature-flux correlation; poison spline gamma activity measurements; and TWFM (traveling wire flux monitor). While several of these methods show ultimate future promise, there are a number of problems remaining to be solved before these techniques can be fully effective. Further, with the possible exception of graphite temperature correlation, these techniques may not lend themselves readily to repetitive use in fixed locations for comparisons of integrated flux history.

The most useful technique currently available for obtaining axial flux data directly relatable to fuel element performance evaluation is heavy metal weaseling. Heavy metal charges have the advantage of yielding (after sufficient decay time) the integrated or average flux for the region in which the metal was charged over the residence time of the fuel in the reactor. It is this integrated or average flux which is of principle interest in rupture analysis and fuel element performance evaluation.

It is the purpose of this production test to designate special tubes in the reactor to be charged with numbered heavy metal pieces for axial-flux distribution. It is further specified that, whenever possible, the PT IP-216-A (Quality Certification metal) be used for this purpose. The use of quality certification production test material will have a two-fold advantage. First, since approximately eight to ten tubes a month per reactor of quality certification metal are now subject to special pickup, the use of this material in designated reactor locations should not appreciably increase the special pickup requirements. Second, data valuable to the quality certification program can be obtained by repetitively charging this material in a limited number of process tubes. The effect of variations in process tubes will have an increasing importance in interpreting the quality certification program data. This will be particularly true in assessing uniform corrosion on bumper fuel elements.

TEST DETAILS

Location of Flux-Monitor Tubes

The specific location for flux-monitor tubes for each reactor are illustrated on temperature maps appended to this production test. At B, D, and F reactors, these tubes comprise a grouping of three tubes in each of five reactor locations; at

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C reactor, six locations are specified and eight locations at the K reactors. At DR and H reactors (because of block discharge), a two-tube grouping at each of five locations is specified. All metal charged into these "flux monitor" tubes should be preferably PT IP-216-A natural material. If PT IP-216-A natural material is not available, numbered charges made up from normal production material should be used. These specific tube locations shall not be changed without the mutual concurrence of the Supervisor of Process Engineering Unit and the Supervisor of Pile Physics Unit. No enriched metal should be charged in these "flux monitor" tubes except at H Reactor. During the E-N production test at H Reactor, charges of PT IP-216-A E-N monitor columns are authorized.

Frequency of Flux Data

All flux-monitor tubes shall be charged with either PT IP-216-A natural material or supplementary numbered charges. These tubes shall be charged in such a manner that approximately one tube from each location will be discharged each month at all reactors except DR and H. At those "block-discharge" reactors, one tube from each location shall be discharged approximately in the middle as well as at the end of the metal cycle. For this reason, only two flux monitor tubes per location is specified for DR and H Reactors. In order to achieve the desired balanced fuel cycle for each location, some discharging of green metal is authorized. The process engineer will recommend initial discharge schedules for these tubes in order to invoke the desired discharge frequency. Production Scheduling Operation will be responsible for subsequently scheduling flux monitor tube discharges so that approximately one tube per month per location will be discharged.

Handling of Discharged Flux-Monitor Charges

All charges discharged from flux-monitor tubes will be picked up special and sorted into individual buckets for each tube charge.* The buckets will be identified as to tube number and date of discharge. After a 20-day decay period, this metal will be made available to Process Engineering for the taking of weasel data. After weasel data has been taken, all PT IP-216-A charges will be sent to C basin for post-irradiation examination by the Component Testing Unit. All supplementary numbered charges (non-PT IP-216-A material) will be returned to the normal irradiated metal flow stream.

Handling of Weasel Data

All weasel data will be recorded on specially prepared IBM program data forms and submitted to Data Processing Operation for IBM calculation of normalized flux shape and relative rupture potential determination. Copies of this data will be made available to the Pile Physicist, Process Engineer, Processing Manager, the Process Analysis Unit, and Pile Physics Unit.

Permissible Alteration in Traversing Procedures

If an alternate method for monitoring the flux distribution is developed and is demonstrated to provide as accurate, complete, and reliable flux data as heavy metal weaseling, and, in addition, a firm schedule is established which provides the minimum required frequency of traverses in the number of zones as specified herein, it may be substituted for the natural uranium monitoring authorized by this production test. Any such change must have prior approval of the Supervisors of Process Engineering Unit, Pile Physics Unit, and the Processing Managers of the affected areas before the heavy metal weaseling schedule is altered.

*If PT IP-216 material can be identified by series number and accurate records are made of tubes in which test material is charged, then sorting in individual buckets will not be necessary.

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RESPONSIBILITIES

Processing Operations

The Processing Operations will be responsible for insuring that PT IP-216-A charges or supplementary numbered columns are charged into the specified flux monitor tube locations and for special pickup and sorting of the irradiated test fuel charges.

Production Scheduling

Production Scheduling will be responsible for selecting discharge goal exposures for the flux-monitor tubes such that approximately one tube per month will be discharged from each reactor location.

Process Engineering Unit

Process Engineering will be responsible for preparing supplementary numbered charges*, as required, weaseling the test charges and submitting the data to the Data Processing Operation for rupture potential calculation, and factoring the results into power level recommendations.

Pile Physics Unit

Pile Physics Unit will be responsible for continuing reassessment of the choice of flux monitor tube locations, for recommending a change in monitor location, if indicated, and for continued improvement in recommended rod usage and E-metal loadings, etc. directed toward more favorable flux configurations.

Process Analysis Unit

Process Analysis Unit will be responsible for overall interpretation of routine axial flux data, and factoring this data into metal performance evaluation.

HAZARDS

No increase in reactor hazards will result from this test. No violation of the process standards is authorized.

COST

The cost of increased outage time for special charging and slightly increased special metal pickup will be borne by the Processing Operations.

The cost of weaseling test material, data handling, and IBM programming will be borne by the Process Engineering Unit.

Supervisor, Process Engineering Unit
Process Technology Sub-Section
Research and Engineering Section

SM Graves:md

*Numbered charges will conform to HW-50377, "Quality Control Standards Fuel Element Manufacturing Process."

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FIGURE 1

Effect of Flux Distortion on Rupture Potential

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FLUX MONITOR
TUBE LOCATIONS - B, D, AND F REACTORS

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The image is a 48x48 grid map of a coastal area. The x-axis is labeled from 320 to 0 at the top and bottom. The y-axis is labeled from 01 to 46 on the left and right sides. A thick horizontal line runs across the middle of the grid at y=24. The coastline is defined by a thick line on the left and right sides. Several 'X' marks are placed on the grid: two at (220, 33), two at (220, 14), two at (160, 27), and two at (40, 33).

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FLUX MONITOR
TUBE LOCATIONS - C REACTOR

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FLUX MONITOR
TUBE LOCATIONS - KE AND KW REACTORS

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