AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

Centimeter

Inches

MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

DECLASSIFIED

DOCUMENT NO.

HW-77121

SERIES AND COPY NO.

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

March 29, 1963

INTERIM REPORT
EXPERIENCE WITH PT IP-467-C
REDUCING MINIMUM DOWNTIME

☐ OTHER OFFICIAL CLASSIFIED INFORMATION
THIS MATERIAL CONTAINS INFORMATION AFFECTING
THE NATIONAL DEFENSE OF THE UNITED STATES
WITHIN THE MEANING OF THE ESPIONAGE LAWS,
TITLE 18, U. S. C., SECS. 793 AND 794, THE TRANS-
MISSION OR REVELATION OF WHICH IN ANY MANNER
TO AN UNAUTHORIZED PERSON IS PROHIBITED
LAW.

AUTHOR

J. R. Fredsall

ISSUING FILE

TECHNICAL RECORD

ROUTE TO:

PAYROLL NO.

LOCATION

FILES ROUTE
DATE

SIGNATURE AND DATE

Indefinite Retention

Disposal Date

Authority

Authority

DECLASSIFIED

DECLASSIFIED

HW-77121

This document classified

by: C. Bowers

This document consists of
29 pages.

Distribution

1-2. AEC-RL00: Attn: AT Gifford/RL Plum	25. AB Greninger
3. AEC-RL00: Attn: CN Zangar	26. CN Gross
4. DG Albertson	27. LL Grumme
5. TW Ambrose	28. RS Hammond
6. ER Astley	29. AK Hardin
7. JW Baker	30. LW Lang
8. JT Baker	31. CG Lewis
9. RS Bell	32. AR Maguire
10. CE Bowers	33. WW McIntosh
11. WA Blyckert	34. AW Medcalf
12. RD Carter	35. R. Nilson
13. RA Chitwood	36. GF Owsley
14. RG Clough	37. CA Priode
15. EL Conner	38. RW Reid
16. DW Constable	39. OC Schroeder
17. RF Corlett	40. SM Skidmore
18. RE Dunn	41. HG Spencer
19. WJ Ferguson	42. WL Stiede
20. EJ Filip	43. RE Tiller
21. JR Fredsall	44. AD Vaughn
22. GC Fullmer	45. AP Vinther
23. SM Graves	46. 300 Files
24. OH Greager	47. Records Center
	48-50. Extras

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

March 29, 1964, Classification Cancelled and Changed To

DECLASSIFIED

By Authority of C.G.-PR-2

US Navy, 3-18-94

By James M. Miley 3-31-94

Verified By DK Harrison, 4-4-94

INTERIM REPORT

EXPERIENCE WITH PT IP-467-C

REDUCING MINIMUM DOWNTIME

INTRODUCTION

The length of the minimum outage, or period of time during which a reactor must remain subcritical following a shutdown from equilibrium, is a direct function of the available excess reactivity. In reactors with unlimited safety system capacities, it is quite feasible to "build in" sufficient excess to allow complete override of the shutdown xenon transient, and thus, in effect, reduce the "minimum downtime" to zero. Present

DECLASSIFIED

HW-77121
Page 2

Hanford production reactors do not possess this unlimited capacity, and thus total pile reactivity must be restricted by minimum safety strength conditions. Any effort to increase the pile reactivity must therefore be tailored to satisfy existing Total Control and Speed-of-Control criteria. Production Test IP-467-C, "Reducing Minimum Downtime,"^{3/} was designed to evaluate the economic benefits of a system in which base reactivity can be increased in periods of minimum control requirements, and correspondingly decreased when reactivity or safety considerations become more demanding.

The partial-override experimental test loading, as prescribed in the parent document, consists of a central block loading of 50 tubes of 0.947 per cent I&E enriched uranium. Each tube in the block is equipped with a spline cap to allow complete neutralization of the added reactivity when it is not needed for startup operation. Operation with the core thus involves insertion of splines for direct compensation (neutralization) of the core during normal operating periods, and removal of these splines prior to cold or secondary cold startups (use of the core reactivity for hot startup approaches-to-critical is not permitted).

The purpose of this document is to summarize initial operating history and results obtained under the production test.

SUMMARY AND CONCLUSIONS

The xenon-override block loading authorized by PT IP-467-C, "Reducing Minimum Downtime,"^{3/} has been used for ten startups; experience with the 50-tube loading has shown that associated operating procedures are within the capabilities of the present operating crews and equipment (some problem was encountered in familiarizing personnel with the special operating conditions of the startups; the high reactivity worths of control rods and splines when inserted into the peaked startup flux distribution required conservative techniques but did not lead to insurmountable flux distribution-control problems).

Analysis of operating data indicates the feasibility of "xenon-override," although net savings for this particular load were not as large as originally predicted. The observed reactivity worth of the 50-tube core concept is about 11 mk (as contrasted to predicted values of 16-23 mk) and is equivalent to about 7.5 hours in reduction of minimum downtime. The average net savings for the ten startups, however, was only 3.0 hours; difficulties in overcoming outage problems, new and unfamiliar startup procedures, and the related slowness of the power increases reduced the efficiency. It is estimated that "fully optimized" utilization of the 50-tube core should result in average effective savings of 5.5 - 6 hours per startup.

Use of larger core loadings would allow correspondingly larger savings; it is estimated that a core of ≥ 175 tubes would be necessary for full override, based on a worth of 11 mk for the 50-tube core. A larger core would also require proportionally more time to charge and discharge compensating splines (with the present core, 20 splines are removed in $\sim 2\frac{1}{2}$ hours). A possible way to reduce poison removal time requirements, by using poison charges in PCCF tubes for compensation, is suggested in reference 9.

DECLASSIFIED

HW-77121

Page 3

Analysis of the data from two enriched core loadings (ten startups) indicates that the xenon-override core can be used to reduce minimum downtime and thus increase total equilibrium operation time. It also provides a convenient means of adding a large amount of reactivity to (or removing it from) the reactor in a short time. It is felt that there is economic incentive to provide some degree of xenon-override (perhaps 100 per cent) by this technique. Firm recommendations will be forthcoming after discharge of the third core loading (and thus termination of the PT) and AEC concurrence on the hazards analysis that is being prepared.

DISCUSSION

During the period 3-10-62 through 1-1-63, at B Reactor the xenon block (core) was in place for about 190 equilibrium days and was used for ten startups during the year (see Table 1). Accumulated startup and operating experience is summarized in the following discussion.

A. Startups with PT IP-467-C

1. The Approach-to-Critical

To reach critical during cold startups, splines were removed from the block following the VSR and HCR withdrawals, as described in reference 3. Spline removal was begun with the centermost spline and was continued radially outward to create unsplined core areas of successively larger sizes. A test restriction requiring at least a three-minute wait between spline removals was not limiting at even the maximum spline removal rate.

Criticality was usually achieved during the core spline pulls. Although the removal of core splines added reactivity at four times the rate for normal spline removals, the rate of reactivity addition was still slower than a normal startup by HCR withdrawal, and presented no problems. Critical approaches by xenon transient decay with all of the core splines removed occurred in three startups. In these instances a reciprocal count rate plot was used to predict critical.

As the spline pulls occurred 20 to 30 hours after shutdown, front face radiation dose rates were low. Typical values were 15 mr/hr on the near side of the elevator and 5 r/hr next to the coiler (background = 5 mr/hr). Approximately 2-1/2 hours were needed to remove the usual core spline loading of 20-26 splines.

2. The Rise to 1 MW Maximum Tube Power

The rise to power was governed by the schedule shown in Figure 2. Under the production test there are three main restrictions on power charges: 1) a pause at $\Delta T_{\max} = 10C$ for a temperature map, 2) a 3C/min limit on increases in $\Delta T_{\max}$, and 3) a 1 MW limit on $W_{\max}$ ($W_{\max}$ = Maximum Tube Power). Adherence to these limits precluded an approach to the overriding 50 MW/min limit of ordinary operation. Compliance with the speed of control limit (as explained in Section C) was reflected in the use of a 20-minute wait at 450 kw and a one-hour ramp to 1 MW for $W_{\max}$ (see Figure 2).

DECLASSIFIED

HW-77121
Page 4

Table 1

Xenon Core Startup Data

Startup Date	3/13	3/20	4/7	7/15	7/24	8/15	10/11	10/25	11/21	11/29
Hours Shutdown	19.4	27.2	30.2	23.5	27.4	29.8	29.0	29.2	28.7	12.9
Xenon at Critical (c-mk)	3527	3316	2863	3120	3097	2650	2874	2850	2965	2961
Core Splines at FI* (c-mk)	0	0	280	0	163	95	180	70	0	70
Non-core Poison at FI (c-mk)	72	109	306	190	55	78	103	52	50	794
Period (c-mk)	0	0	0	134	20	60	52	37.5	65	65
Rods at FI (c-mk)	0	0	90	90	45	45	90	35	20	65
E. MWD/Tube	34.6	40.9	48.7	26.0	31.1	27.1	40.5	37.9	32.3	32.3
He at TA, %	80	80	69	81	75	75	80	75	53	78
TA Poison (c-mk)	546	600	906	680	817	866	691	838	921	906
TA Level, MW	1170	1175	1350	1050	1250	1200	1300	1300	1200	1350
Operating Days** with Load	0.5	6	20	79	86	2	46	58	64	68

*FI - First Indication

**The first load was charged on 3-10-62 and discharged 8-7-62; the second core load was charged on 8-9-62 and discharged on 12-13-62. The third core was charged on 1-24-63.

DECLASSIFIED

HW-77121
Page 5

On all startups the initial flattening efficiency was about 18 per cent. This increased as the maximum tube power (W_{max}) was raised but was not particularly sensitive to the schedule used to increase W_{max} . For example: On the first four startups W_{max} was raised to 1 MW in 1-1/2 hours rather than the 1 hour shown in Figure 2, but there was little difference in the time variations of the flattening efficiency. This suggests that over-all startup efficiency is not strongly dependent upon rate of rise to 1 MW W_{max} ; the startup efficiency attributable to this part of the startup is probably already limited by the rate of xenon burnout and graphite heating.

During the rise to full power, pile reactivity increased because of xenon burnout and graphite heating. This added reactivity was controlled by spline and rod insertions. In most cases it was possible to complete the splining of the core (19 splines) by the time the 1 MW tube power was reached. At this rate of spline insertion 5-rod alone was sufficient for control. In every instance, after 19 core splines had been inserted it was possible to return to operation by standard procedures.

Instrument sensitivities are important in reactor safety considerations. For core startups the sensitivities are less than normal because the reaction is strongly localized in the center of the reactor - farther than normal from the instrument-sensing chambers. Data from the last four core startups indicate that the peaked flux condition at equal powers reduces the relative readings on the flux monitors and galvanometer to 40 per cent, and for the subcritical monitor, 80 per cent of their normal values. This reduction in sensitivity is almost insignificant in the sub-megawatt ranges when viewed on the over-all exponential scale of shutdown to operating flux level.

3. Turnarounds

The rise to turnaround proceeded on a normal basis as soon as the core had been completely splined, as the limits of the production test were then no longer in effect. The main inconvenience during this period was the necessity of using 120-110 per cent high trip settings on the flux monitors. In fact, it was usually necessary to have two instrument technicians on hand for every startup, one to watch the flux monitors, and one to roll flow-monitor gages.

The flux distribution behavior during the rise to turnaround was similar to that of hot startups; the flux peak location first changed from the core to the far side of the front face plane as a result of rod and spline insertion; subsequent peaks occurred in the areas above and below the rod banks. Non-core supplemental poison requirements for turnaround were about the same as for startups at the normal minimum downtime. The core itself needed no additional poison above the 19 cancellation splines. Turnaround occurred roughly six to seven hours after first indication, and about five hours after the 1 MW maximum tube power was reached (see Figure 4). This long period required for turnaround (four hours after FI for normal minimum startup) was an important limiting factor in determining the over-all startup efficiency; thus some improvement in efficiency may be realized by increasing the turnaround level.

DECLASSIFIED

HW-77121

Page 6

B. Predicted and Experimental Results

Some characteristics of xenon-core startups were predicted in the parent document^{/3/}. This discussion compares these and other predicted values with experimental values.

1. The Flux Shape

The actual startup flux distribution (20-minute curve in Figure 5) was pleasingly similar to the theoretical radial flux curve (Figure 5). The observed radial flattening efficiency was 18 per cent compared to predicted efficiency of 15 per cent.^{/3/} The observed variation of the radial flux during the rise to turnaround, also shown in Figure 5, was determined by averaging the flux distribution along the four radii extending from the center of the core to the four corners of the front face. The flux distribution flattened more slowly than originally estimated.^{/3/}

The axial flux distribution through a splined core is shown in Figure 6. It is significant that no peaking of the flux distribution was observed along the enriched portion of the charge.

2. Spline Worth

The reactivity worth of a center spline in the core was predicted as 162 c-mk^{/3/}, whereas the measured worth was 115 c-mk; the calculated effect probably is in error because it was calculated by one-group diffusion theory, which tends to overestimate the reactivity effect of strong localized absorbers. Figure 7 shows the observed variation of the spline worth in an otherwise unsplined core versus distance from the core's center.

Also shown in Figure 7 is the worth of splines residing outside the core during a core startup. The measured spline worths for splines in tubes 3772 and 2583 compare well with the results of a one-group diffusion theory calculation made as a check. This calculation indicated that a localized change in flat zone buckling (outside the enriched core) during a core startup had 83 per cent of the reactivity effect of the same buckling change during a normal startup; it should be pointed out that this ratio is considerably higher than would be predicted by flux-squared weighting techniques.

3. Core Reactivity Worth

The core reactivity worth was originally estimated at 16-21 mk^{/3/}; the best experimental value determined to date, however, was 11 mk. This value was observed during the rod calibration of 6-25-62.^{/4/} It was possible to determine accurately the worth of the core at this time since criticality was obtained with the core both splined and unsplined, with no xenon burnout between. The apparent core worth was 11.4 mk, but this has been reduced to 11 mk to correct for the reduction in reactivity worth of the flat zone poison (see Section 2). Eleven mk is equivalent to 7.5 hours in the reduction of minimum downtime after a shutdown from equilibrium at 1850 MW.

DECLASSIFIED

HW-77121
Page 7

Data from other startups generally support the value of 11 mk, at least to the accuracy of cold startup predictions (± 75 c-mk). However, additional experimental determinations of the core reactivity worth by the method employed on the outage of 6-25-62 should be made before uncertainty limits are assigned.

A determination of the core buckling (B_c^2) required to produce a reactivity effect of 11 mk was made with the one-dimensional one-group diffusion theory code Vitabuck. The following input was used.^{/1/}

Region	Outside Radius (Cm)	B_m^2 (μb)	Contents
1	85	68 to B_c^2	Core
2	357	68	Flat zone, Natural U
3	392	184	Enrichment ring
4	519	60	Fringe, Natural U
5	582	32	Augmentation region

The reactivity of any given loading is proportional to the uniform reactor buckling change required to return the reactor to criticality; the core buckling that results in a pile reactivity of 11 mk (the observed case) was found to be 220 μb . With a core buckling (B_c^2) of 220 μb , a core of 175 tubes will have a reactivity of 42 mk, the amount necessary for complete xenon override; early calculations predicted 118 tubes.^{/3/}

C. Speed-of-Control Considerations

The speed-of-control limit for PT IP-467-C has been derived elsewhere^{/6/}; the limits applicable to the present case are shown in Figure 8. A complicating factor in assuring compliance with this limit is that no existing reactor graphite stringers are near enough to the core to directly measure the graphite temperature in the core during a startup. Therefore, the graphite temperature variation was estimated by a method described below:

The average temperature in any given graphite stringer is given by^{/2/}

$$\bar{t}_s = \frac{\bar{t}_o + t_i}{2} + \left[a + \frac{b}{11 N_H + N_C} \right] \bar{W} \quad (1)$$

where: $\bar{t}_s$ = average stringer temperature

$\bar{t}_o$ = average outlet temperature of eight surrounding tubes

t_i = inlet temperature

a and b = constants depending on reactor

N_H and N_C = per cent He and CO₂ respectively

$\bar{W}$ = average power of eight surrounding tubes

DECLASSIFIED

HW-77121

Page 8

This equation, which describes a system containing a stringer, can be modified to calculate the maximum graphite temperature (T_m) along a given tube when no stringer is available.

According to the referenced work^{/2,12/} this maximum temperature may be calculated from the equation:

$$T_m = t_i + 0.91 W (0.102 + d) \quad (2)$$

where: $d = 0.5$ at 60% He and 0.48 at 80% He.

The solution of this equation at 60% He is shown in Figure 8 (Curve A).

The graphite temperature transient in a reactor is described by the differential equation:

$$\frac{dT}{dt} = c_1 w - \lambda T \quad (3)$$

where: w = local power, and $\frac{1}{\lambda} = T_f$, the graphite temperature

"falling period" ($T_f = 60$ minutes at B Reactor)

The solution of this equation for a step change in w to w' is:

$$T = T_0 + \frac{c_1 w'}{\lambda} (1 - e^{-\lambda t}). \quad (4)$$

For the ramp change $w = w_0 + c_2 t$,

$$T = T_0 + \frac{c_1 w_0}{\lambda} (1 - e^{-\lambda t}) + \frac{c_1 c_2}{\lambda^2} (t + e^{-\lambda t} - 1). \quad (5)$$

By setting $w = w_{\max}$, the maximum tube power, $T_{\max}$ can be calculated. The variation of $T_{\max}$ at 60% He during the one-hour ramp (illustrated in Figure 2) is given as Curve B in Figure 8. This curve was calculated by first using equation (4) to find $T_{\max}$ at the end of 20 minutes at $w_{\max} = 450$ kw; this $T_{\max}$ was then substituted for T_0 in equation (5).

The speed-of-control limit curve is given in terms of the flux-square-weighted graphite temperature ($\bar{T}$). To convert $T_{\max}$ to $\bar{T}$, one must multiply by a linear correction factor (Q) which is dependent on the flux distribution. Figure 9 illustrates the method used to arrive at the Q values. Curves 1 (theoretical startup flux), 2, 3, 4 and 5 were considered as flux distributions representative of those expected with a core startup. The assumption of a cosine axial flux distribution then allowed the calculation of Q (where $Q = \bar{T}/T_{\max}$) for each of the radial distributions. Figure 8 shows the variation of $\bar{T}$ under two assumed conditions: 1) The flux distribution does not change as the maximum tube power is increased (Curve D), and 2) The distribution varies as in Figure 3 (Curve C). Assuming the latter case, the speed-of-control limit is satisfied. It was also found that the gas composition has a small effect on the graphite temperature during the power ascension (4% variation per 20% change in Helium).

DECLASSIFIED

HW-77121

Page 9

D. Equilibrium Operation and Current Status

Equilibrium operation with the core fully compensated by splines presented some unforeseen problems. The main problem with the original core loading was that the outlet temperatures of the core tubes were higher than the surrounding tubes of natural uranium by about ten per cent. This was caused by two things: 1) Reduced flow in the core tubes, and 2) The fact that enriched metal produces more power for a given flux level. Three reasons for the lower core flow (higher flow resistance) were: 1) Bumpered enrichment was used (normal uranium slugs are "unbumpered"), 2) The core charges had more slug junctions per charge, and 3) Each charge had an upstream dummy train. The resulting high temperatures of the core tubes required the insertion of about 6-7 additional splines. This in turn caused a flux depression in the core and a loss in reactivity.

The second core loading was charged on 8-9-62 and consisted of 50 tubes with three downstream I&E, 29 I&E² and four upstream I&E.^{10/} This charge was shorter by two downstream and one upstream I&E pieces than the original charge, but resulted in tube temperatures 3-4 per cent above the surrounding tubes. The charges used on the third load have nonbumpered fuel but still have about two per cent less flow than the surrounding natural charges.

The reactivity worths of splines or HCR's routinely inserted into the core region do not differ noticeably from their pre-core values. A possible adverse effect of the core is that it could contribute to power oscillations in the front face plane. (These are possible since opposite portions of the reactor are separated by a fairly black region - a situation that could make these portions tend to act independently of each other.) As yet, however, no instability problem has been observed.

The original production test prescribed limits for the spline pattern to be used to compensate the core; it was found that the routine splining of the hot tubes in the core during operation kept the pattern well within these limits.

E. Costs and Savings

The objective of this production test is to demonstrate the feasibility of using an enriched core loading to reduce minimum downtime. The original estimates of the savings^{3/} were overly optimistic because the reactivity of the core was overestimated; the average savings for the first ten startups, assuming a core worth of 11 mk, are listed in Table II, and Appendix 3 lists the data for individual startups. Two explanations are postulated for the randomness of the data shown: 1) The startup efficiency is greatly influenced by the particular problems of each startup, and 2) The NEL (nonequilibrium loss) for a startup followed by a short operating period is not strictly comparable to normal startup NEL's.

The "gross possible savings" were calculated as the difference in startup times for the reactor with and without the core splined and with no other poison in the reactor. The "gross actual savings" were always less than the possible savings because some supplementary poison was in place for all startups (the startups were slightly delayed).

DECLASSIFIED

HW-77121
Page 10

The NEL (nonequilibrium loss) is the net loss in days of full power operation incurred during startup (a consequence of the conservative approach to equilibrium level). For normal startups NEL averaged 0.311 day for 1962. The "net savings" are the gross actual savings minus the increase in NEL over normal startups.

The net savings figures given in Table II indicate that the actual production gains realized thus far with the core are marginal. However, it should be pointed out that no credit has been assumed for use of the core reactivity to occasionally override the reactivity effect of supplemental poisons.

Table II
Core Startup Statistics
(Data from the first ten core startups)

	Gross Poss. Savings	Gross Act. Savings	Δ NEL	Net Savings	Potential Work-Time Lost	Poison Removal Time Sav.	TA Poison Savings
Average	8.3 Hrs.	5.4 Hrs	+0.098 days	3.0 Hrs	6.4 Hrs	-1.0 Hrs	-9 Splines
Largest	+13.9	+7.7	+0.309	+8.8	+9.7	+3.3	+25
Smallest	+6.8	+2.4	-0.098	-1.0	+0.2	-2.3	-17

Graphical Explanation of Terms

cc = cold reactor reactivity

Gross Possible Savings = BE (B is earliest possible startup time)

Gross Actual Savings = CE (C represents the time of a typical startup after some delay BC)

Δ NEL = (NEL)core startup - (0.311 days)avg NEL for 2C noncore startups in 1962

Net Savings = Gross Actual Savings - Δ NEL

Potential Time Lost = AD (Time during which normal outage work could have been performed)

Poison Removal Time Saved = DE-AC (Shorter time required for equivalent poison removal)

TA Poison Savings = TA poison requirement for startup at minimum without the core minus actual poison inserted for TA (core)

DECLASSIFIED

HW-77121
Page 11

(These poisons were usually left in the reactor because of reactor outage scheduling difficulties.) In fact, in some cases the poison insertion necessary for turnaround including core poison was markedly less than normal. (For example, during the startup of 11-29-62 a savings of 25 spline insertions was realized.)

The net savings with the core have also been restricted because it was usually impractical to reach critical at the earliest possible time. If true minimum outages had been accomplished, the total savings for ten startups would have been 57 hours of full-power operation instead of 30 hours. Some improvement is to be expected as more core startup experience is gained, but it is probably impossible for the average core startup efficiency to equal that of normal startups. (See Figure 4). The most desirable improvement that could be made for the present core would be to provide a system of core poisoning that would allow a faster rate of poison removal; one such alternative is described in reference 9, which proposed a system using mint charges in PCCF tubes.

Total spline costs to date have been about \$3820 (\$15 per spline); outage time for the charging of the three cores was about 27 hours. E-metal costs have been equivalent to approximately \$110,000 per year in excess of normal uranium burn-out costs.^{13/} Total exposure received to the average three-man crew on startup was about 250 mr/man on core spline removals, and 400 mr/man during the core spline insertions.

JR Fredsall
File Physics Unit
Operational Physics Sub-Section
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

JR Fredsall:gs

DECLASSIFIEDReferences:

1. HW-70780 - An Operational Reactivity Accounting System Based on One-Group Diffusion Theory, 4-1-62, G.F. Bailey
2. HW-71309 - Calculation of Pile Graphite Temperatures from Reactor Operating Data, 10-11-61, C.M. Heeb
3. HW-71809 - Production Test IP-467-C - Reducing Minimum Downtime, 12-6-61, J.F. Jaklevick
4. HW-71809, Sup. A - PT IP-467-C Sup A, Horizontal Rod Calibration During Reduced Minimum Downtime - B Reactor, 4-6-62, A.D. Vaughn
5. HW-71957 - Reducing Minimum Downtime - A Nuclear Safety Analysis, 5-9-62, J.F. Jaklevick, G.F. Owsley
6. HW-72073 - Speed of Control Limits for Xenon Override Production Test, 1-4-62, R.E. Tiller
7. HW-73105 - Interim Report - PT IP-467-C, Reducing Minimum Downtime, 3-22-62, G.F. Owsley
8. HW-73930 - Production Test IP-467-C, Sup. B - Reducing Minimum Downtime - K Reactors - 6-6-62, R.A. Chitwood
9. HW-73981 - Poison Compensation with the Xenon Override, 6-12-62, G.F. Owsley
10. HW-74039 - Production Test IP-467-C, Sup. C - Reducing Minimum Downtime, 6-19-62, G.F. Owsley
11. HW-75206 - Interim Report - PT IP-467-C, Sup. A - Horizontal Rod Calibration at B Reactor During Xenon Override Startup - 10-9-62, A.D. Vaughn
12. Personal communication, E. Leitz, February 1962
13. Personal communication, R.D. Carter, March 1963

DECLASSIFIED

EW-77121
Page 13

Figure 1

The Xenon-Override Block in B Reactor

DECLASSIFIED

HW-77121.
Page 14

DECLASSIFIED

HW-77131
Page 15

Figure 3

Variation of Radial Flattening Efficiency
Maximum Tube Power (1 hour ramp)

DECLASSIFIED

Comparison of Typical Xenon Core Startup
with a Normal Startup

Figure 4

Radial Flux Variation after a PT IP-467-C Startup

Figure 5

DECLASSIFIED

DECLASSIFIED

HW-77121
Page 18

DECLASSIFIED

HW 77121
Page 19

DECLASSIFIED

HW-77132
Page 2

Graphite Temperature Variations (Speed of Control Considerations) During Startup*

Figure 9

Development of the Flux-Squared-Weighting Factor

DECLASSIFIED

HW-77121
Page 22

Appendix 2

Data From Core Startups

Startup Date	Gross Poss. Savings (Hrs)	Gross Act. Savings (Hrs)	Δ NEL* (Days)	Net Savings (Hrs)	Potential Work-Time Lost (Hrs)	Poison Removal Time Sav. (Hrs)	TA Poison Savings (Splines)
3-13-62	8.2	7.7	0.275	+1.1	9.7	-2	-15
3-20-62	6.9	6.4	0.309	-1.0	8.1	-1.7	-12
4-7-62	6.8	3.2	-0.098/	+5.6	2.9	+0.3	- 2
7-15-62	7.7	6.1	0.145	+2.6	7.2	-1.1	-11
7-24-62	7.3	5.5	0.102	+3.0	7.2	-1.7	-16
8-15-62	7.1	2.4	-0.062	+3.9	3.4	-1.0	-14
10-11-62	7.4	5.4	0.164**	+1.5	7.2	-1.8	-12
10-25-62	7.4	6.6	-0.092/	+8.8	8.4	-1.8	-17
11-21-62	7.6	7.0	0.185**	+2.6	9.3	-2.3	-16
11-29-62	13.9	3.5	0.061	+2.0	0.2	+3.3	+25

*NEL - Nonequilibrium losses

**Includes a scram after critical

/NEL was low because reactor was shut down shortly after startup.

DECLASSIFIED

HW-77121
Page 23

Appendix 3

Annotated Bibliography of Xenon-Override Documents

1. HW-71809 - An Operational Reactivity Accounting System Based on One-Group Diffusion Theory, 4-1-62, G.F. Bailey - the original production test. It contains the main rules for administering the test.
2. HW-71809 - PT IP-467-C, Sup. A, Horizontal Rod Calibration During Reduced Minimum Downtime - B Reactor, 4-6-62, A.D. Vaughn - gives methods to be used in HCR calibration at core startup.
3. HW-71957 - Reducing Minimum Downtime - A Nuclear Safety Analysis, 5-9-62, J.F. Jaklevick, G.F. Owsley - a discussion of the effect of the core loading in total control requirements.
4. HW-72073 - Speed of Control Limits for Xenon-Override Production Test, 1-4-62, R.E. Tiller - the speed of control limit to be applied to xenon-core startups.
5. HW-73105 - Interim Report - PT IP-467-C, Reducing Minimum Downtime, 3-22-62, G.F. Owsley - a discussion of the core startups of 3-13-62 and 3-20-62.
6. HW-73930 - Production Test IP-467-C, Sup. B - Reducing Minimum Downtime - K Reactors - 6-6-62, R.A. Chitwood - the extension of the test to K reactors. A 68-tube core is proposed.
7. HW-73981 - Poison Compensation with the Xenon Override, 6-12-62, G.F. Owsley - a discussion of core compensation poisoning. Li-Al compensation is proposed.
8. HW-74039 - Production Test IP-467-C, Sup. C - Reducing Minimum Downtime, 6-19-62, G.F. Owsley - authorization of two recharges of the xenon-override block. A modified charge is to be used.
9. HW-75206 - Interim Report - PT IP-467-C, Sup. A - Horizontal Rod Calibration at B Reactor During Xenon Override Startup - 10-9-62, A.D. Vaughn - a presentation of the results of the calibration authorized by HW-71809, Sup. A.

DATE

FILMED

8/12/94

END