AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

(CLASSIFICATION)

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

72-197
HW-72947

SERIES AND COPY NO.

DATE

January 29, 1962

☒

RESTRICTED DATA
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 TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

TITLE

CHARACTERISTICS OF SPLINES
FOR FINE DISTRIBUTION CONTROL

☐

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 TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

AUTHOR

R. D. Carter

ISSUING FILE

THIS DOCUMENT MUST NOT BE LEFT UNATTENDED OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. WHEN NOT IN USE IT MUST BE STORED IN AN APPROVED LOCKED RECEPTACLE WITHIN AN APPROVED GUARDED AREA. WHILE IT IS YOUR RESPONSIBILITY TO KEEP IT FROM BEING LOANED A SIGNED RECEIPT FROM CLASSIFIED FILES, IT IS YOUR RESPONSIBILITY TO KEEP IT FROM BEING LOANED TO ANY OTHER PERSON. IT IS YOUR RESPONSIBILITY TO, AND STORAGE IN YOUR PLACE OF RESIDENCE IS PROHIBITED. IT IS NOT TO BE REPRODUCED, IF ADDITIONAL COPIES ARE REQUIRED, OBTAIN THEM FROM THE RELATED ISSUING FILE. PERSONS READING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE PROVIDED BELOW.

ROUTE TO:

PAYROLL NO.

LOCATION

FILES ROUTE
DATE

SIGNATURE AND DATE

R.D. Carter 17352 1760D FEB 1962 RDC 2/1/62
P.D. GROSS 14424

RECORD
COPY

Indefinite Retention

Disposal Date

Authority

Authority

54-3000-340 (3-57)

AEC-GE RICHLAND, WASH.

(CLASSIFICATION)

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DECLASSIFIED

DECLASSIFIED

HW-72497

Energy Act

any manner to an unauthorized person is prohibited

Distribution

1. DG Albertson	25. RR Henderson
2. ER Astley	26. JH Hoage
3. E Bailey	27. CG Hough
4. JT Baker/RC Haynes	28. F Jape
5. JW Baker/JE Rice	29. HF Jensen
6. RE Barr	30. AR Kosmata
7. RS Bell	31. DS Lewis/RK Wahlen
8. JH Brown	32. AR Maguire
9. RD Carter	33. DI Monnie
10. RA Chitwood	34. SL Nelson/GO Amy
11. RG Clough/WG Albert	35. DE Newbrough
12. DW Constable	36. R Nilson
13. RF Corlett/G Fiorelli	37. GF Owsley
14. RE Dunn/JR Pierce	38. CA Priode
15. JH Ferguson	39. RW Reid
16. WJ Ferguson	40. GJ Rogers
17. EJ Filip	41. DE Sebade
18. JR Fredsall	42. SL Stewart
19. GC Fullmer	43. AD Vaughn
20. SM Graves	44. AP Vintner/IL Huffman
21. OH Greager	45.-46. Extra
22. CN Gross	47. Record Center
23. LL Grumme	48. 300 File
24. AK Hardin	

This document classified

by: MC Fullmer

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of WA SnyderCG PR-2, 3-7-94By G E Savely 3-16-94Verified By DK Hanson, 3-28-94This document consists of
14 pages. No. 9 of
48 copies. [REDACTED]

January 29, 1962

CHARACTERISTICS OF SPLINES FOR FINE DISTRIBUTION CONTROL

MASTER

INTRODUCTION

The introduction of poison splines as an operating aid at the Hanford reactors has resulted in an impressive production increase.^{1/} This increase is mainly due to the effect on startup control and to better equilibrium flux shaping (flattening). In providing sufficient reactivity effect for startup control, however, present splines sometimes increase rather than decrease flattening and distribution control problems when utilized during

^{1/} HW-69979, "Spline-Induced 1960 Production Gains," R.D. Carter, 6-19-61

DECLASSIFIED

HW-72497
Page 2

equilibrium operation. In addition, being of constant poison strength along their length, they have limited effectiveness for axial flux control and shaping.

It has therefore been proposed that in addition to the present spline, the use of two other types of splines with finer reactivity effects might be advantageous. These splines are as follows:

1. To reduce large rod movements and increase flattening efficiency - a spline with uniform poison distribution along its length but only about 50 per cent of the present spline reactivity strength (to be noted hereafter as a "grey" spline).
2. To increase axial flux control and shaping - a spline with poison only on the downstream end, no poison on the upstream end (to be noted hereafter as a "half" spline).

SUMMARY AND CONCLUSIONS

Splines with the following specifications could be used to promote more efficient reactor operation with little or no adverse side effects:

1. Grey Spline - (a) Eight per cent by weight B_4C , 0.050 inches in thickness, 0.300 inches in chord width, or (b) In case that sealing problems inherent with the above dimensions cannot be solved, 6 per cent by weight B_4C , 0.045 inches in thickness and 0.450 inches in chord width.
2. Half Spline - 15.6 per cent by weight B_4C , poison length of 19 feet, nonpoison length of 27 feet (these lengths are for experimental purposes only; optimum lengths will be determined after further experimentation), 0.045 inches in thickness, 0.470 inches in chord width.

Other specifications, e.g., weld junctions, solutions to any sealing problems, identification as to type, etc., are beyond the scope of this document.

The splines listed above are calculated to induce a relatively lower rupture rate in the splined charge than in an unsplined charge, and an over-all tube corrosion rate not significantly different than at present. The rate of reactivity change due to burnout of the neutron absorber is compatible with operational requirements.

DISCUSSION

Following the introduction of the present splines an evaluation of the problems of application indicated that additional spline types were desirable. Specifically, a weaker (or grey) spline was desirable for radial flux shaping during equilibrium operation to reduce overpoisoning of sections of the reactor, and a spline with poison on only half its length was necessary to permit axial flux shaping and control, thus decreasing the tube rupture potential.

The parameters which define satisfactory spline operation are (not necessarily in order of importance):

1. Neutron absorber content (in this case the boron in B_4C).
2. The physical dimensions.

DECLASSIFIED

HW-72497

Page 3

3. The change of the reactivity effect due to interactions with the thermal neutron flux (burnout).
4. The effect on tube rupture potential and tube corrosion.
5. Satisfactory sealing with the standard spline seal.
6. Adequate tensile strength.
7. Adequate resistance to bending or kinking during insertion.

The best splines to fit the above criteria were then selected as follows:

Boron Content and Spline Dimensions

To determine the effect of the first two parameters, splines with three different amounts of boron carbide - 5, 10 and 15 per cent - were obtained. Thirty-inch samples of each concentration were then modified either in width or thickness or both. Two samples each of identical (or as nearly as possible) specifications were then tested. The table below shows the selection of sample specifications.

Table I

Nominal Dimensions of Spline Samples

Width Inches	Thickness - Inches					
	.050	.045	.040	.035	.030	.025
1/2	X	X	X	X	X	X
7/16	X					
3/8	X			X		
5/16	X					
1/4	X			X		

Thus, 24 samples for each B_4C concentration for a total of 72 were tested.

The samples were reduced in width by a normal machining operation. The reduction of thickness was accomplished chemically because of difficulty of reducing the curved surfaces of the spline.

Since the chemical bath not only reduced the thickness of the samples but also the width, the dimensions were not always identical with those on the table. The machining operation to reduce the width did not always result in a uniform width because of difficulty in holding the curved spline and the hardness of the B_4C . Dimensions were measured every five inches along the spline and then averaged.

The use of a chemical bath in reducing the spline thickness also resulted in pitting of the spline surface. Chemical analysis showed that some B_4C was removed from the surface resulting in a lower B_4C density when compared to the spline thickness as checked with a micrometer. Normalizing the density to that of an untreated sample an equivalent thickness was obtained. This last value was used in comparing reactivity effects of dimension changes.

DECLASSIFIED

HW-72497
Page 4

The 72 spline samples were all tested for reactivity strength in the Hanford Test Reactor (305 Pile). All reactivity values were normalized to the average of the two samples of regular spline specifications. Results are shown in Figure 1.

The desired strength for the grey spline was assumed to be 50 to 60 per cent of a regular spline although this range of values was chosen arbitrarily. Relative reactivity strengths over 60 percent were not considered to be enough variation to warrant a different spline type since some variation in strength is possible by not inserting a spline full length. Less reactivity strength required spline specifications that would probably not be compatible with mechanical strength or burnout requirements.

On this basis, a new set of curves was drawn which showed the variation of thickness, width and B_4C density necessary to obtain 50 per cent reactivity strength (Figure 2). These curves were obtained from the data in Figure 1. Since tensile strength is dependent on geometric cross-section, a second family of curves appears on Figure 2 which shows lines of constant geometric cross-section relative to a regular spline.

Burnout Considerations

The approximate decrease in spline poison strength as a function of the number of operating days was calculated by assuming that a spline has a reactivity strength of a given number of milli-k. This was equated to the proportion of pile neutrons absorbed by the spline. The number of boron atoms in the spline was determined and the per cent burnout was calculated from an assumption of pile power level and the number of neutrons released per MWD. The splines were divided into eight regions and the burnout calculated for each region by a slug-factor-squared weighting.

The rate of decrease of spline strength should not be so rapid that the spline would have to be replaced at frequent intervals. Decreasing spline strength in a reactor at equilibrium will allow a long term creeping power increase in the splined region. In the past this has not been noticeable since splined areas are usually "overpoisoned." With a 50 per cent reduction in strength a more rapid burnout rate is involved. Flattening splines are left in the reactor 30 days or longer an appreciable number of times. If we assume that 10 per cent burnout is not limiting, we can use an approximate limit for spline operation no more than 10 per cent burnout in 30 operating days.

Regular splines used for total control are usually assumed to have 10 per cent less than full strength. Burnout of such splines should therefore not be greater than 10 per cent unless burnout is considered in total control calculations.

Reactivity burnout for several spline types were calculated (Figure 3). Specific data is shown in the table below:

Table II

Burnout Rates

Type	Specifications				Operating Days	
	% B_4C	Width	Thick.	Rel. Poison Strength	10% B.O.	20% B.O.
I	15	.470	.050	1.00	73	134
II	8	.300	.050	0.50	38	68
III	4.25	.470	.050	0.50	23	45
IV	6	.450	.045	0.585	27	53

Type I is a regular spline. Types II, III and IV are variations of a grey spline. (Type numbers have no significance except to permit easier identification within this document.)

THE SENSEI

- Relative Power/unit length = rel. x-section $\times \frac{20,000}{15}$

DECLASSIFIED

DECLASSIFIED

Type II was selected as the spline having 50 per cent of strength of the regular spline (see Figure 2) and the best combination of tensile strength, resistance to buckling, low burnout rate and low flow resistance. However, this spline is not compatible with the present spline seals. Unless some provision can be made to ensure adequate sealing it may not be acceptable.

Type III is a spline having 50 per cent of the strength of the original spline and the same dimensions. The amount of B_4C in this spline is low (4.25 per cent) and the burnout rate is relatively rapid. Ten per cent burnout occurs at 23 operating days compared to 38 days for Type II and is significantly faster than the limiting conditions selected above.

Type IV is a spline having the minimum dimensions compatible with good spline sealing, .450 inches thick and .045 inches wide. To decrease the burnout rate the amount of boron was increased by selecting a relative reactivity strength close to .60. Since six per cent B_4C gave a relative strength of .585 this composition was used. With this spline 10 per cent burnout occurred at over 27 operating days which is close to the 30 days previously selected as a limit. This spline could probably be used as an alternate to Type II.

Mechanical Properties

Tensile strength of a spline should be proportional to the geometric cross-section. Therefore from the standpoint of greatest tensile strength a spline having the greatest geometric cross-section is required. Also, for a given reactivity strength, greater boron content per unit length results in a slower burnout rate. Therefore it is desirable from both the standpoint of tensile strength and burnout to obtain the greatest cross-section for a given boron content and reactivity strength.

If we assume that for 50 per cent reactivity strength about eight per cent B_4C is the minimum desirable concentration from the standpoint of burnout rate, from Figure 2 we find that for a spline of 50 per cent reactivity strength and no dimension greater than the regular spline the specifications are:

Thickness	-	0.050 inches
Width	-	0.30 inches
% B_4C by weight	-	8

This results in a spline having a relative geometric cross-section of about 64 per cent that of the present splines which would indicate a relative tensile strength of 64 per cent. However, tensile tests^{/2/} indicate a slight increase in strength as the B_4C density decreases. Therefore the relative strength would probably be in the range of 65 to 70 per cent.

Resistance to buckling of a spline with the above dimensions should be more than adequate. Tests by W. Dalos^{/3/} indicate that a spline with the above dimensions would buckle at about 55 to 65 pounds force on the handle of the spline inserter. The normal spline insertion force is 10-20 pounds and the normal maximum is 40 pounds.

Sealing

The tests by W. Dalos also showed that sealing was not adequate for spline widths less than about 7/16 inch or thicknesses less than about .045 inch with some possible reservations because the tested samples did not all have the same edge finish as the regular

^{/2/} Private Communication from W. Dalos, 9-29-61

^{/3/} Ibid

spline. However, it is believed possible to obtain an adequate seal with splines of smaller width than 7/16 inch by the use of plastic inserts, use of a full sized end piece, or redesign of the seal. Therefore the spline seal problem may not be restrictive.

Effect on Slug Ruptures

The expected number of ruptures in a tube is a function of local surface temperature, power and exposure. The local temperature is correlated to the bulk outlet temperature by:

$$r = \frac{\Delta T_i}{\Delta T_B}$$

where T_i is the local temperature and T_B is the tube outlet temperature.

The rupture rate is assumed equal to $k P^{3.3} T_i^{8.7} E^5$ where P is the power and E is the exposure. (Since power and therefore exposure are assumed to be constant around the fuel element, P and E may represent tube power and exposure.) E is also Pt , where t is the time; therefore,

$$R = k P^{8.3} T_i^{8.7} t^5$$

but since $T_i = r \Delta T_B$

$$R = k P^{8.3} (r \Delta T_B)^{8.7} t^5$$

In the normal state of affairs the reduction in rib height and the corrosion of the tube wall as the tube grows older result in an increase in the local temperature for the bottom of the tube and decrease for the top; so the highest r value is generally assumed to be adequate. However, for the case of a spline insertion the local temperature in the top may not decrease, and the bottom temperature and the bulk outlet temperature will increase resulting in a decrease in the r value at the top. This results in an erroneous calculation of the rupture rate increase unless the top and bottom are considered separately. Therefore we must write:

$$\begin{aligned} R &= k' \left[P^{8.3} (r_a \Delta T_B)^{8.7} t^5 + P^{8.3} (r_b \Delta T_B)^{8.7} t^5 \right] \\ &= k' (P)^{8.3} (\Delta T_B)^{8.7} \left[r_a^{8.7} + r_b^{8.7} \right] t^5 \end{aligned}$$

where a and b represent the highest r values in the upper and lower halves of the tube respectively.

If a spline insertion results in a higher rupture rate, then the worst case is for the spline inserted the entire life of the charge. The relative rupture rate, R_r between a charge without a spline and one with a spline will then be:

$$R_r = \left(\frac{P'}{P} \right)^{8.3} \left(\frac{\Delta T_B'}{\Delta T_B} \right)^{8.7} \left[\frac{(r_a')^{8.7} + (r_b')^{8.7}}{(r_a)^{8.7} + (r_b)^{8.7}} \right]$$

where the primes represent the values with a spline inserted.

DECLASSIFIED

HW-72497
Page 10

From previous work^{/4/} we can determine the changes around the annulus with two different types of splines inserted in a new process tube, a regular spline and a twenty mil thick spline with no boron and hence no reactivity effect. From tests at B, D, DR and F reactors it was determined that for the insertion of a regular spline the flow decrease was 5 per cent and the decrease in tube power relative to the surrounding tubes was about 7.1 per cent. Assuming that a regional power decrease of 4 per cent was normally desired (instead of the initial decrease of about 7 per cent) and that this was maintained by proper control rod adjustment we find that the over-all decrease in spline tube power is about 12.3 per cent.

The values of r change as the ribs wear and the process tube corrodes. Data from Ferguson's test was normalized to curves showing the change in r_a and r_b ^{/5/} with tube corrosion index. Ferguson's data involved a new tube. It was assumed that the data obtained from HW-71206 was representative. The data for the r values with no spline in the tube was normalized to the curves, and the data for spline insertion was made relative to it. It was assumed that the shapes of the curves of r_a and r_b were identical with increasing corrosion index to the curves without splines. Admittedly the data is meager but it is applied in a logical manner.

Assuming that the addition of a poison spline changes the power uniformly over a slug and that the incremental changes in power and temperature for columns containing grey splines are proportional to the incremental changes in poison strength within those parameters represented by the regular spline and a nonpoisonous spline, we may obtain the data in Table III.

Table III

Relative Rupture Rates and Associated Data

Spline Type	-	I	II ₀	II ₁₀	II ₂₀	IV	V	VI
%B ₄ C	No spline	15	8	8	8	6	0	0
Thickness		0.050	0.050	0.050	0.050	0.045	0.020	0.050
Width		0.50	0.300	0.300	0.300	0.450	0.470	0.470
% Burnout		0	0	10	20	0	-	-
Rel. React.		1.000	0.50	0.45	0.40	.585	0	0
Rel. Tube Flow	1.000	.950	.952	.952	.952	.950	.955	.950
Rel. Tube Pwr.	1.000	.877	.938	.944	.950	.928	1.000	1.000
Rel. Out ΔT	1.000	.923	.985	.992	.998	.977	1.047	1.053
New Tube:								
r_a	1.072	1.018	1.018	1.018	1.018	1.018	1.018	1.018
r_b	.925	1.005	.991	.991	.991	1.005	.984	1.005
R_r	1.000	.158	.461	.516	.579	.415	1.30	1.48
40 mil Tube:								
r_a	.981	.925	.925	.925	.925	.925	.925	.925
r_b	1.086	1.164	1.152	1.152	1.152	1.164	1.145	1.164
R_r	1.000	.248	.702	.786	.881	.650	1.94	2.32

/4/ HW-71206, "Test of Nonpoisonous Splines," J. H. Ferguson, 9-29-61
/5/ Private communication from C. J. Hough

DECLASSIFIED

The data indicate that the rupture potential for the column containing a full length grey spline of proposed dimensions is less, up to at least 20 per cent B_4C burnout, than with no spline inserted. Therefore we should be able to use the proposed grey spline, dependent upon a satisfactory solution to the spline seal problem, without penalty.

The minimum permissible reactivity strength may be calculated by setting R_r equal to 1.000 which implies no increase in rupture rate of a splined tube over a nonsplined tube. If we then assume a full-sized spline and a 40 mil tube wall thickness as the worst case, we can assume conservatively values of r_a and r_b corresponding to the 15 per cent B_4C spline.

Since the incremental changes in tube powers and temperatures are proportional to the reactivity effect of a spline we can then show that for R_r equal to unity the minimum reactivity of a full size spline is slightly less than 40 per cent of a regular spline. If therefore we have a relative spline strength of no less than .40 with any combination of boron content and poison burnout and with any flow restriction equal to or less than that for the regular spline, we can say that such a combination is not restrictive from the standpoint of fuel ruptures.

The half-spline should use the maximum possible poison strength in the downstream section and no poison in the upstream section to obtain the greatest skewing effect. If we assume that the regular spline has the greatest practical poison strength, the poison end of the half-spline will be the same composition as the regular spline. If the upstream end is full sized but has no poison, from Table II we can obtain R_r values for each section. From the Nola-2^{76/} flux traverse program we can obtain flux traverse data which show a rupture potential for each slug in a charge. Using these data, we can calculate (Fig. 4) the variation in rupture potential of a tube with a half-spline inserted relative to one without a half-spline as a function of the length of the nonpoison section in slug lengths (the downstream section containing poison). Curve I assumes that originally the flux was a cosine distribution and that the insertion of a half-spline of the above composition, but of any combination of poison and nonpoison lengths, results in the maximum flux being skewed five slugs upstream of the centerline and peaked 8.5 per cent above a cosine. Curve I shows that the relative rupture potential would be only .9 that of the cosine for a half-spline whose nonpoison section length was up to half the length of the active zone. Curve II assumes the flux skewed two slugs downstream and peaked 5.8 per cent above a cosine prior to the insertion of a half-spline and that insertion of a half-spline results in no change after insertion. The rupture potential relative to a cosine is initially 1.88 (prior to spline insertion). With no change assumed in the flux peak location, the nonpoison section inserted to 16 slug lengths results in a rupture potential only 48 per cent of the original.

Therefore in neither extreme case would a half-spline result in potential loss as long as the nonpoison section is limited to half the active zone length. A tube with a 40 mil wall thickness was selected as the extreme case of a worn tube in which a spline is likely to be inserted, because of the difficulty of inserting splines in older tubes.

The length of the initial group of half-splines to be used for experimental purposes can be determined from the various reactor dimensions. The poison section should be the equivalent of two-thirds the K Reactor charge length to allow determination of the optimum length for the poison section. This is 19 feet. The ends may then be cut to the desired size. The nonpoison section should preferably be short enough that this section cannot be inserted deeper than the middle of a given slug column, requiring different lengths for the older reactors and K reactors. The initial experimental group of splines will be under the close control of a responsible engineer in the Operational Physics Sub-Section.

DECLASSIFIED

Figure 4

Rupture Effect of Half-Spline
vs. Length of Non-Poisson Section

- I - Max. Flux 8.5% above cosine, 5 slugs upstream
- II - Max. Flux 5.8% above cosine, 2 slugs downstream

DECLASSIFIED

HW-72947
Page 13

In order to simplify initial experimental usage under closely observed conditions a single type of half-spline should be obtained whose upstream end is the longest required (27 feet for a K reactor including one foot outside the cap). The splines will be reduced to the desired dimensions prior to use.

In addition a 45 mil thick spline is desirable rather than a 50 mil spline since it is felt that some insertion problems may be alleviated with slightly thinner splines.

Tube Corrosion

Increased process tube corrosion could occur as the result of the long-term irradiation of a spline if there were an increase in local water temperature. Increased local water temperature will result if flow reduction is greater than power reduction.

The local corrosion rate of a process tube may be described approximately by:

$$CR = k_e \cdot 0.57 (T_i + r \Delta T_B) \quad /7/$$

where T_i is the inlet temperature, $(T_i + r \Delta T_B)$ is the outlet temperature corrected to local conditions and the other terms are as previously defined.

This equation is not exact but conforms to the model presently used.

The relative corrosion rate between a splined tube and a nonsplined tube may be written as:

$$\begin{aligned} \text{Rel. CR} &= \frac{k_e \cdot 0.57 (T_i + r' \Delta T_B')}{k_e \cdot 0.57 (T_i + r \Delta T_B)} \\ &= e^{0.57 (r' \Delta T_B' - r \Delta T_B)} \\ &= e^{0.57 r \Delta T_B \left(\frac{r'}{r} \frac{\Delta T_B'}{\Delta T_B} - 1 \right)} \end{aligned}$$

Using the data in Table II the following relative corrosion rates were calculated:

Table IV

Relative Corrosion Rates, $\Delta T_B = 100^\circ\text{C}$

Spline Type	I	II ₀	II ₁₀	II ₂₀	III	IV	V	VI
New Tube:								
Top	.47	.68	.70	.73	.68	.64	.97	1.00
Bottom	1.01	.34	1.39	1.44	1.47	1.38	1.83	2.14
40 Mil Tube:								
Top	.48	.68	.70	.72	.68	.64	.93	.98
Bottom	.93	1.32	1.39	1.44	1.42	1.34	1.40	2.25

DECLASSIFIED

HW-72947
Page 14

Since tube corrosion in the bottom of the tube is most limiting to tube life only the relative values for this region need be considered. The data indicate no significant increase in tube corrosion rates for the regular spline and probably a slight decrease.

For the grey splines an increase of 30 to 40 per cent is indicated. However, it must be remembered that these numbers represent only instantaneous rates. About ten grey splines would be expected to be in the reactor at any one time and the tubes affected would change with the variation of local reactivity requirements. Since there are well over 100 tubes with spline caps on the reactor it should be presumed that grey splines would be inserted in a given tube for only about 10 per cent of the tube life, resulting in an actual increase in corrosion rates of closer to 3 to 4 per cent rather than 30 to 40 per cent. Variation of spline cap locations and the necessary use of regular splines rather than grey splines in a number of cases should limit further any increase in corrosion rates of tubes used for spline insertion.

Spline V is intended for use as a flux traverse device and would have little effect on tube life because of a 15 minute residence time.

Spline VI would be used only as the upstream part of a half-spline. The effect on tube corrosion rates would be less than that shown in Table IV for the same reasons as given for the grey splines. A further decrease would result from the fact that the upstream section of a half-spline would be in a maximum water temperature of about half the ΔT_B used in the calculations.

Process Physics Studies
Operational Physics Sub-Section
Research and Engineering Section

RD Carter:gs

**DATE
FILMED**

8/8/94

END