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DATE
February 16, 1959

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PT-IP-158-D, SUPPLEMENT B
IRRADIATION OF ONE SWAGED UO_2 STAINLESS STEEL CLAD FUEL ELEMENT IN A KE FRONT TO REAR TEST HOLE

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AUTHOR
R. K. Marshall

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PT-IP-158-D, SUPPLEMENT B
IRRADIATION OF ONE SWAGED UO_2 STAINLESS STEEL CLAD FUEL ELEMENT IN A KE FRONT-TO-REAR TEST HOLE

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DS Lewis, 12-21-93
By Jerri Maley, 4-21-94
Verified By J E Savely 4-22-94

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

PRELIMINARY REPORT

"This report was prepared only for use within General Electric Company in the course of work under Atomic Energy Commission Contract W-31-109-Eng-52. Any views or opinions expressed in the report are those of the authors only."

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PT-IP-158-D, SUPPLEMENT-B

IRRADIATION OF ONE SWAGED UO_2 STAINLESS STEEL CLAD FUEL ELEMENT IN A KE FRONT-TO-REAR TEST HOLE

OBJECTIVE

The objective of this supplement is to authorize a change in the panellit trip range from 25-75 psi to 5-95 psi.

SUMMARY

The original production test authorized the irradiation of one, three-foot-long fuel element in test hole 3865 KE. Supplement A authorized the extension of the goal exposure from 1735 MWD/T to 5000 MWD/T.

The test hole facility consists of two concentric aluminum tubes which extend from the front face to the rear face of the reactor. The ID of the inner tube is 2-7/8 inch. Water from one crossheader supplies the annulus, water from another crossheader supplies the inner tube. The three-foot-long, .570 inch OD fuel element is centered in a 40-inch long aluminum holder which has an ID of 1.380 inch and an OD of 2.800 inch. The holder and fuel element are positioned in the inner tube downstream of the centerline of the graphite so that the fuel element generates a maximum specific power at one end of about 4.9 KW/FT The average specific power generation is about 3.7 KW/Ft During normal operation the flow through the inner tube is about 35 gpm with about 31 gpm through the holder and four gpm around it.

JUSTIFICATION

The panellit gage which monitors the flow to the inner tube fluctuates to such an extent during start-up that on two occasions the reactor was scrammed. During equilibrium operation the panellit gage reading remains stable. A possible explanation of this behavior is that during start-up aluminum spacers which are in the inner tube as part of the test charge chatter and cause variations in the water path through the tube. It is further surmised that at equilibrium operation the pressure drop across the column in the tube is sufficient to suppress the chattering.

An anchor charge was placed up stream but did not noticeably reduce the fluctuations of the panellit gage. It is concluded that extending the trip range to 5-95 psi will reduce the possibility of scramming without increasing any hazards to the reactor.

TECHNICAL BASIS

The present trip limits of 25-75 psi result in a reactor scram if the flow through the fuel element holder drops to a minimum of about 27 gpm. The 5-95 psi limits will allow the flow through the fuel element holder to drop to about 22 gpm before the reactor is scrammed. See Figure 1. Calculations predict that at this flow rate the surface temperature of the jacket will be 58 C above bulk water temperature. See Figure 2. It is concluded that such trip limits will not endanger the safety of the reactor.

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RESPONSIBILITY

KE Processing Operation will be responsible for the operational safety and production continuity of the reactor. R. K. Marshall and A. B. Blasewitz, Irradiation Testing Operation have the responsibility for the Research and Engineering Operation's interests.

R K Marshall

R. K. Marshall
Irradiation Testing Operation

RK Marshall:bmr

[redacted]

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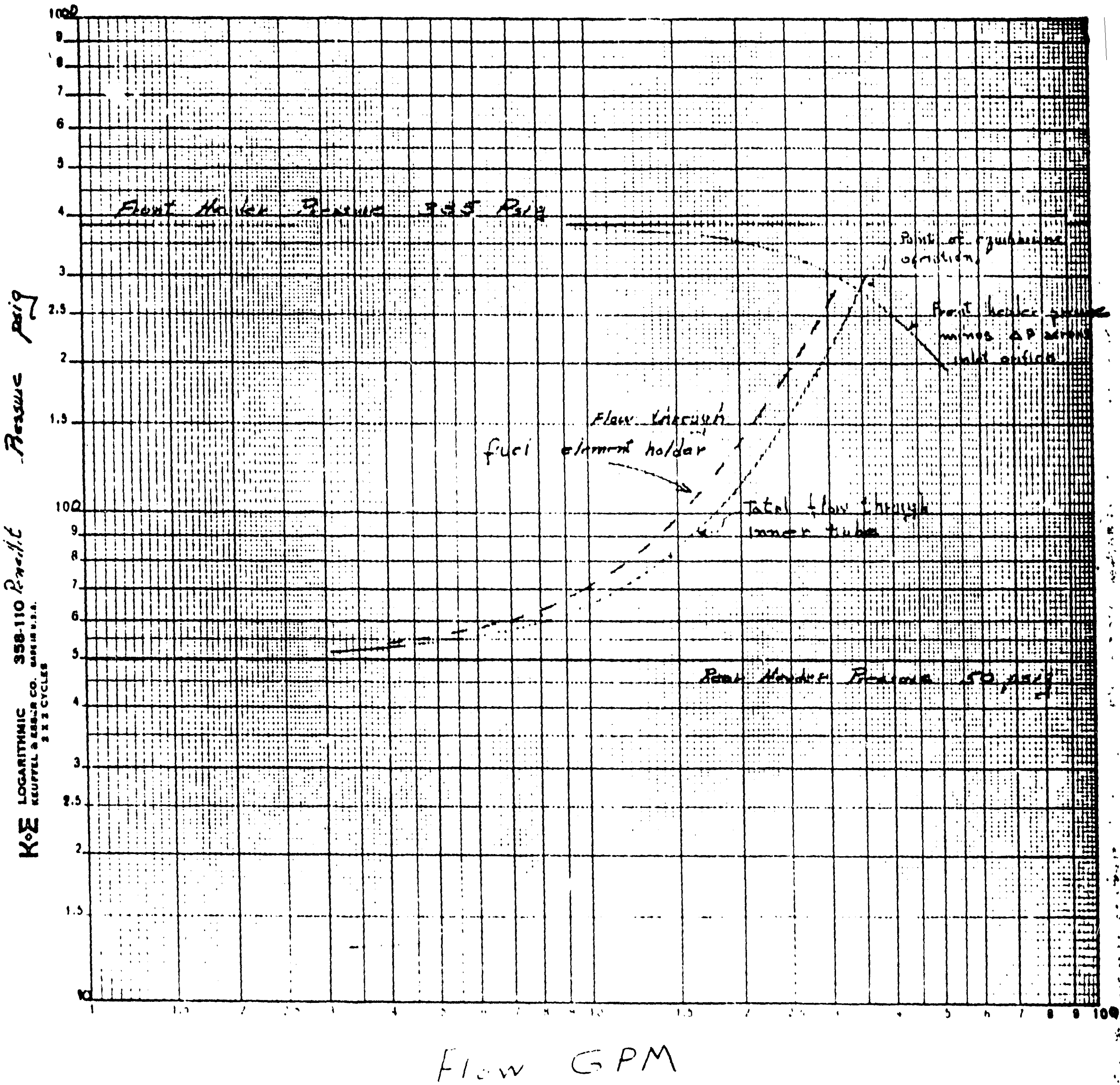

Figure 1

[redacted]

K+E 10 X 10 TO THE ½ INCH 358-11
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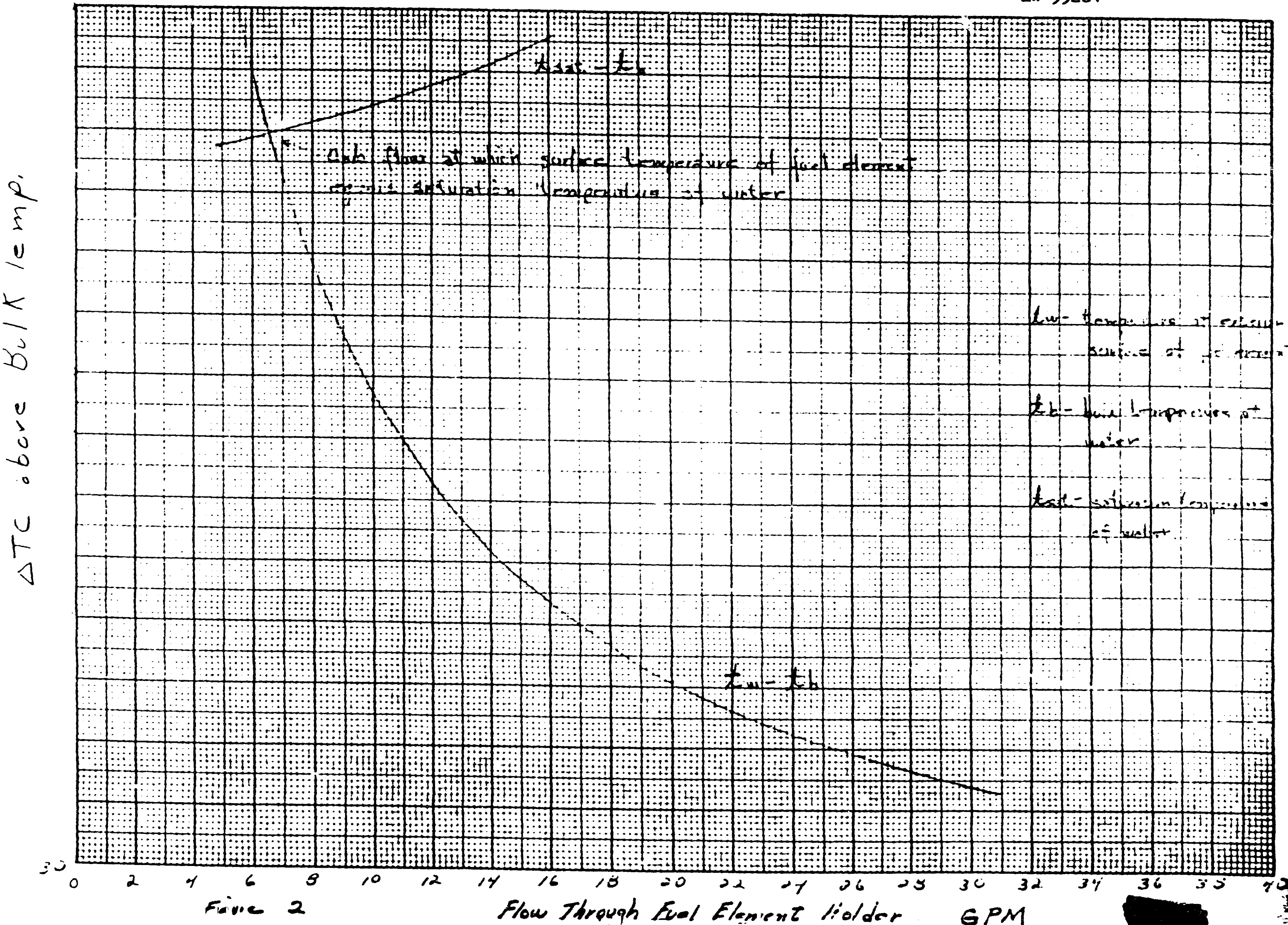

Figure 2

[redacted]

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APPENDIX

Calculations

Case considered: Flow reduction caused by restriction upstream of the fuel element.

DATA

1. Calculations based on maximum specific power of 4.9 KW/FT. (16,700 B/hrft) which occurs at one end of the fuel element.

2. Maximum heat flux 1.12×10^5 B/hrft^2.

3. Average power generated 3.7 KW/FT.

4. Inlet water temperature assumed to be 20 °C.

5. ID of flow passage in which fuel element is centered 1.380 inch.

6. OD of stainless steel clad fuel element 0.570 inch.

7. Saturation temperatures ; a) 151 °C at 55 psig
   b) 156 °C at 65 psig
   c) 175 °C at 115 psig

8. Cross sectional area of flow path through fuel element holder .00863 ft^2.

9. Area of heat transfer/foot of fuel element 0.149 $\frac{ft^2}{ft}$

10. Film coefficient.

    a. $\frac{h\,De}{K} = .023 \left[\frac{De\,G}{\mu}\right]^{.8} \left[\frac{\mu\,Cp}{K}\right]^{.4}$

    b. $h = K_t \frac{V^{.8}}{De^{.2}}$ B/hrft^2 F

    c. V in ft/sec

    d. De in ft $= \frac{\left[D_2^2 - D_1^2\right]}{(D_2 + D_1)} = D_2 - D_1$ $\qquad D_2 = OD$, $D_1 = ID$

    e. $D_e^{.2} = \frac{1.380 - .570}{12} = \left[.0675\right]^{.2} = 0.584$

    f. K_t from Fuel Element Technical Manual HW-40000

    Figure III-2. K_t @ 20 °C = 160

11. ΔT_{wf} = Drop across water film . $q' = hA\,\Delta T_{wf}$

[redacted]

12. ΔT_{fe} = Rise in water temperature $q = WC_p \Delta T_{fe}$

Results - Plotted as Figure 2

Flow through Fuel Element Holder gpm	Vel. through Fuel Element holder Ft/sec	$V^{.8}$	h B.Hrft^2	ΔT_{wf} C	ΔT_{fe} C	Tsat- Tbulk C
30	7.76	5.15	1410	44	1.5	
20	5.18	3.73	1020	61	2.1	174.
10	2.59	2.14	587	106	4.2	154.
5	1.29	1.23	337	184	8.4	147.

Reynolds No. at 5 gpm:

$$N_{Re} = \frac{De\ G}{\mu} = \frac{(.0675)(5)(498)}{2.71 \quad .00863} = 7200$$

[redacted]

APPROVALS:

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KE & KW REACTORS OPERATION

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9/7/94

END