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[illegible] 10-16-90
[illegible] 11-2-90
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This document consists of 6 pages. [redacted]

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November 3, 1954

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PNL 10-90

SLUG RUPTURE OUTBREAK AT H PILE

INTRODUCTION

The recent occurrence of an excessive number of slug ruptures, approximately half of which were stuck, has held the operating efficiency at H Pile to a very low level. This document presents information pertinent to these failures, steps which have been taken to remedy the situation, and a possible reason for their occurrence.

SUMMARY AND CONCLUSIONS

1. During the month of October 1954, slug ruptures occurred in 17 H Pile tubes within an area [illegible] rows high and eleven rows wide.

2. It is concluded that the outbreak resulted from the unusual operating conditions. A localized hot-spot of short duration probably occurred during a rapid startup. The conclusion is supported by (a) the fact that the ruptures are located in a localized region of the pile, (b) the lack of correlation between rupture and/or near rupture and metal type, and (c) data indicating the possible occurrence of such an event during at least one startup.

3. To prevent further ruptures in the region, tubes have been discharged as knowledge of the extent of the damaged region has been obtained by (a) location of the ruptures, and (b) examination of metal discharged from tubes.

4. A determination of whether tube pushes have completely eliminated the defective region can only be gained through further operation.

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DISCUSSION

Occurrence and Possible Causes

During the month of October, 1954, slug ruptures occurred in 17 H Pile tubes in an area ten rows high and eleven rows wide. In addition to the high density of ruptured pieces within a tube, as many as three being found in one tube, a number of "near ruptures" were discovered. In the past, slugs evidencing such indentations have disclosed cracks in the uranium underneath.

The pattern of failure occurrence, beginning in a small area and later extending outward from this area in all directions, as shown in Figure 1, indicates the possibility of some detrimental condition in the region where the failures began, that decreased in severity with distance from the spot. This could have been a "hot spot" during non-equilibrium operation, in which metal at the center of the "rupture area" operated at powers far above normal for some period of time, and the powers decreased along a smooth curve with distance from this point. It has been noted that this area is the "hottest" in the pile, frequently during scram recoveries and occasionally during poison column startups.

During a startup on October 3, 1954, it was noted that tubes in the center of the pile had attained outlet water temperatures of approximately 100 degrees. If the flux pattern at this time were that frequently encountered during such startups, the metal in the rupture area would have been operating at powers far above normal. "Near ruptured" slugs from this region are to be examined by the Radiometallurgy Unit in the near future in order to determine whether the pieces had achieved powers sufficient to transform the cores into the beta phase.

An examination of the manufacturing data for these pieces shows that failures were sustained by triple-dip canned metal, by lead-dip canned metal and by reprocessed metal which was first triple dip canned and later lead-dip canned. Ruptures occurred in metal cast at both Fernald and Mallinckrodt, the two current casting sites. Thus the metal in this region was made up of essentially all types of uranium slugs currently undergoing irradiation, and was similar to the metal throughout the pile. Metal quality can therefore be discounted as a possible cause.

Metal damage due to some event occurring on a header may also be eliminated, since such an event should initiate failures all along the header rather than in a relatively small region on one side of the pile. Also, failures have occurred in tubes on five different headers, and the occurrence of the same detrimental event to five separate headers is improbable.

When the first of these failures occurred, the proximity of several relatively fresh enrichment charges, "C" metal columns and "J-Q" columns, was suspected as a possible cause. It was thought that possible flux distortions caused by the enrichment pattern might cause part of the length of the normal uranium columns in adjacent tubes to run abnormally hot. However, if this were the case, ruptures should occur in other regions of the pile where similar metal, at comparable exposures, is operating in essentially the same position relative to enrichment columns. Figure 2 shows the positions of rupture tubes along with the position of the enrichment columns in H Pile. As yet, there has been no indication of failures extending to these other regions. It is possible, if some flux distortion due to an operating condition were responsible, that the presence of the enrichment columns would increase the distortion.

Because of an apparent "shift" from a slow to a fast rising period during the startup of October 3, it has been conjectured that a small portion of the pile might have become "critical" of itself. A discussion of this possibility follows: "Even had the local lattice characteristics been sufficiently reactive, the rest of the pile would act as a reflector and show the same rate of rise; therefore, after the local flux became high enough to give an indication on the under-pile monitoring chambers, the rising period measured should have been taking place at all points in the pile. This "shift" could have been the result of improper instrument adjustments which would produce non-linear response, or it might have resulted from a normally minor rod tip withdrawal from the near side of the pile which was abnormally reactive at time of startup. It is recognized that distortions which shadow the instrumentation and thereby decrease its sensitivity can take place, but within the instrument's range of sensitivity it should indicate the true pile period as long as no change is simultaneously made in rod configuration."(1)

Sequence of Ruptures and Action Taken

On October 4, 1954, slug ruptures occurred in tubes 3057 and 3058, on October 8, a slug rupture occurred in tube 2958 and, on October 12, ruptures occurred in tubes 3156, 2956, 3056, 3155, 3059, and 2862.

During the shutdown to discharge these last ruptures, nine additional tubes at exposures above 400 MWD/T were discharged from this area. Slugs from eight of these tubes appeared to be in good condition; however, the metal from the ninth tube, 2959 H, disclosed six "near ruptures". All other charges in the area from row 27 to 32, inclusive, and from columns 54 to 64, inclusive, with the exception of "C" and "J-Q" charges, were backseated and perf swab readings were taken in order to discover any additional failures. No high readings were found. Rupture tube 3056 was recharged with numbered solid aluminum dummies for a flux traverse.

From October 15 to October 17, ruptures were discharged from tubes 2758, 2756, 3257, and 2954. At this time, all charges over 400 MWD/T exposure from row 26 to 33 and column 54 to 63 inclusive were discharged. Tubes 1557 and 2953 were also discharged for inspection in the hope of detecting a tendency for the failures to spread to these regions. Inspection of the metal from non-rupture tube 3359 disclosed two near ruptures. Six near ruptures were discovered in the metal discharged from non-rupture tube 2656. Metal from all other non-rupture tubes discharged at this time appeared to be in good condition.

Weasel readings of a column of solid aluminum dummies which had been in tube 2760, between two "J-Q" columns, during two days of operation showed no abnormal flux distribution along the tube.

On October 23, a rupture occurred in tube 2864, on October 25, ruptures occurred in tubes 3457 and 2964, and on October 28, a rupture occurred in tube 2556. During the shutdown for the latter rupture, twenty-five additional tubes were discharged.

Pertinent slug rupture data for the ruptures are presented in Table 1:

(1) G.C. Fullmer to J.K. Anderson, Personal communication, 11-2-54.

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DATA ON H PILE RUPTURES AND NEAR RUPTURES

Tube Number	Discharge Date	Charge Date	Tube Exposure	Type(1) Metal	Number of Ruptures	Number of Near Ruptures	Type Failure	Remarks
3057-H	10-4-54	3-14-54	649	"A"	1	2	Split	Stuck
3058-H	10-4-54	5-15-54	478	"B"	1	4	Split	
2958-H	10-8-54	5-15-54	495	"B"	1	0	Split	
3156-H	10-12-54	5-25-54	454	Z	1	Uninspected	Split	
2956-H	10-12-54	5-25-54	444	Z	3	1	Split	
2862-H	10-12-54	4-30-54	581	"A"	1	1	Split	Stuck
3056-H	10-12-54	5-25-54	449	Z	2	7	Split	Stuck
3155-H	10-12-54	3-14-54	610	"A"	1	10	Split	Stuck
3059-H	10-12-54	5-25-54	484	Z	1	4	Split	Stuck
2959-H	10-12-54	5-25-54	479	Z	0	6		
2758-H	10-15-54	5-25-54	467	Z	1	3	Split	Stuck
2756-H	10-17-54	3-15-54	638	"A"	2	6	Split	
3257-H	10-17-54	5-15-54	510	"B"	2	2	Split	
2954-H	10-17-54	2-24-54	576	19-M	1	10	Split	Stuck
2656-H	10-17-54	3-14-54	639	"A"	0	6		
3359-H	10-17-54	4-21-54	615	"A"	0	2		
2864-H	10-23-54	5-1-54	592	"A"	1	0	Split	
3457-H	10-25-54	5-15-54	517	"A"	1	0	Split	
2964-H	10-25-54	4-30-54	599	"A"	1	0	Split	
2556-H	10-28-54	2-24-54	707	"A"	1	3	Split	Stuck

(1) "A" is smooth surfaced, triple-dip canned slugs. "B" is smooth surfaced, lead-dip canned slugs. Z slugs are recanned pieces. These Z slugs which ruptured were originally triple-dip canned and were recanned by the lead-dip method.

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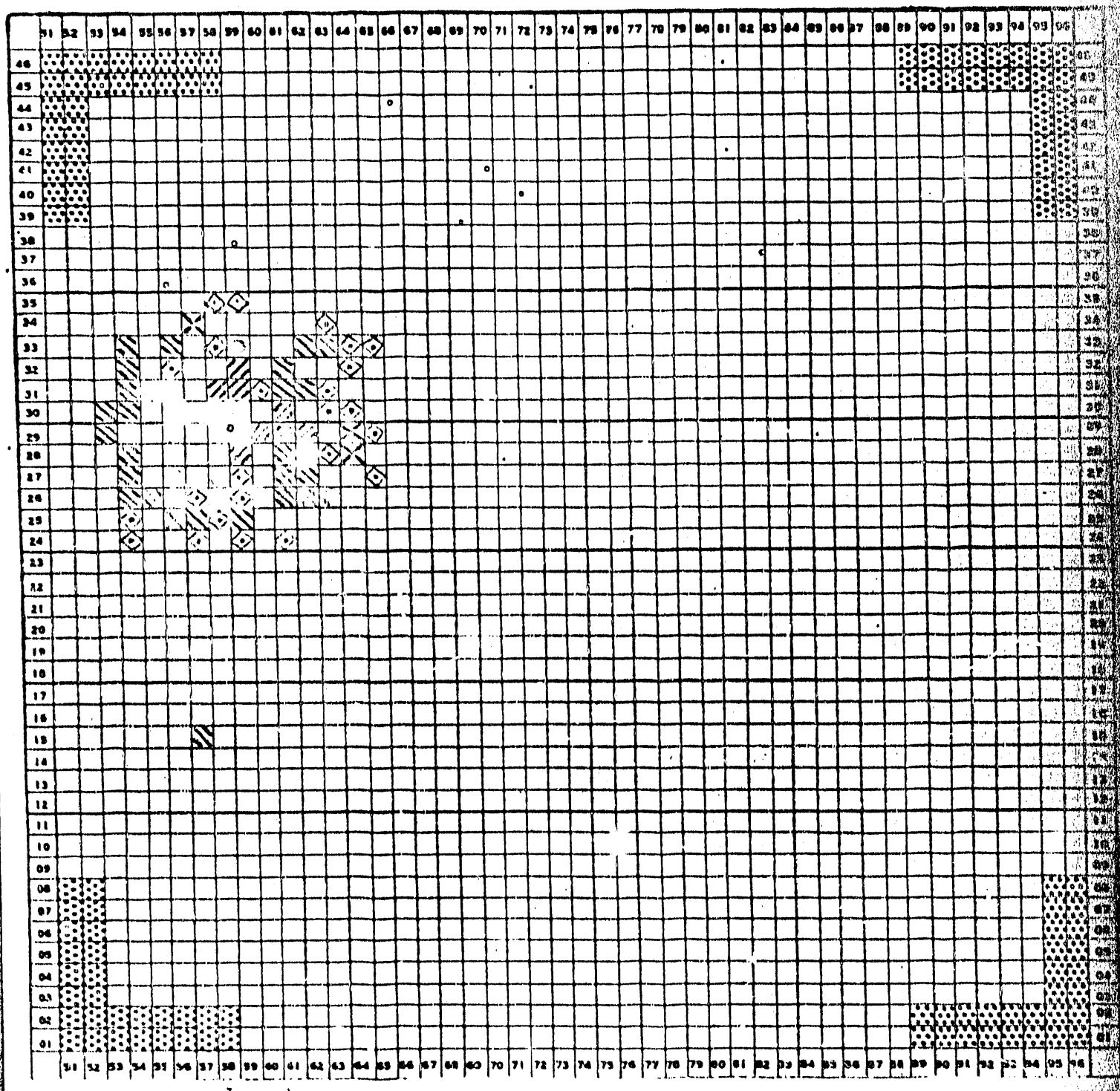
FIGURE 1: Distribution of failures and discharges at H Pile, October 1954



Legend:

- Ruptures or near ruptures discharged 10-4-54 thru 10-12-54.
- Discharged 10-12-54. No ruptures or near ruptures found.
- Ruptures or near ruptures discharged 10-15-54 thru 10-17-54.
- Discharged 10-17-54. No ruptures or near ruptures found.
- Ruptures or near ruptures discharged 10-23-54 thru 10-25-54.
- Discharged 10-25-54. No ruptures or near ruptures found.

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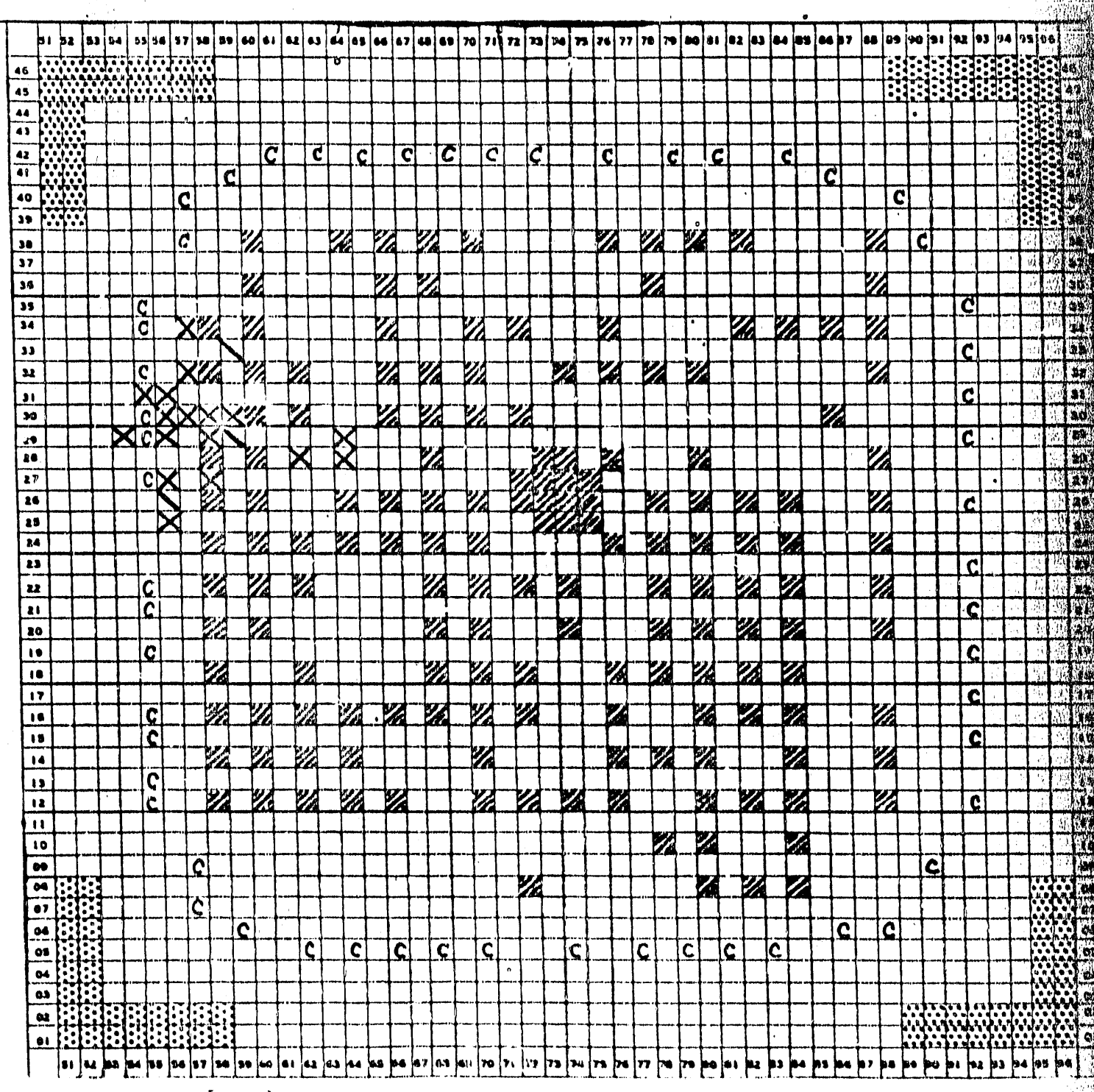
FIGURE 2: Distribution of October 1954 failures at H Pile with respect to enrichment columns.



Legend:

- "C" Metal enrichment columns.
- "J-Q" Metal columns.
- Ruptures discharged 1-4-54 thru 10-5-54.
- Near ruptures discharged 1-4-54 thru 10-5-54.

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