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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

TITLE

FLUX DISTRIBUTION PROBLEMS AT C REACTOR

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March 15, 1960
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RM 4-30-73

FLUX DISTRIBUTION PROBLEMS AT C REACTOR

INTRODUCTION

A recent outbreak of ruptures, January and February, 1960, has motivated serious consideration of all phases of reactor operation so that a combined effort to reduce rupture potential might be made. Items investigated include mixer location, gas composition control, rod movement, rod configuration, tube power, and the axial flux profile of the reactor.

SUMMARY

The most informative were the front-to-rear flux traverse data, whose analysis indicated a region in the center of the pile consisting of about 400 tubes that exhibited rear peaking and skewing. Furthermore, the peaking was found to be as high as 20 per cent and located four pieces downstream of the charge center. Even more important was a marked depression at about the 26 piece from the rear. (Figure I.)

The recommended plan for improving the C Reactor flux problem is as follows:

The immediate steps have been:

1. Displace the enrichment loading (spike enrichment) in the problem region 24 inches upstream.
2. The application of a restrictive temperature limit to the central portion of the reactor as a function of seven rod position.
3. An accelerated program for the taking of flux traverse data to monitor changes and improvements. Graphite thermocouple data have been used to determine peaking trends also.

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Long range plans:

1. Obtain flux traverse as often as possible in the problem area and initiate a flux taking pattern that will in the future define regions where changes occur.
2. Borescope more rod channels and use the electromagnet (1) to remove balls currently lodged in the reactor.
3. Attempt removal of balls in the following hoppers first:

20
19
18
17
16
26
24

Preferably in that order.

4. During future ball drop tests either drop balls so that fewer become lodged using the trickle drop method (2) suggested or at the time of the ball drop have ball drop equipment operable. Another suitable method is to use fast burnout balls such as cadolinium containing ceramic balls.
5. Consider using an enrichment loading with the enrichment located at about the 25 piece for many of the regular metal charges in depressed region. Either this or complete ball removal is the only real solution.
6. Provide C Reactor Process Manager with information as it becomes available and continue flux profile improvement until a satisfactory distribution is attained.

DISCUSSION

It seems worth while to ponder for a moment the probable cause of the front depression. A typical traverse of a tube in the problem region is shown in Figure I, and it is indicative of what one would expect if a great deal of poison were located there. Front rods are not located that far upstream and normally are positioned short, < 30 per cent in, so it could not be due to them.

Routine ball drops have occurred occasionally for quite some time. These tests demonstrate the operability of the Ball 3X system and must be performed periodically. Until the last test on 11-8-59 no record of the amounts of balls lost was maintained, and for that test alone 280 pounds were lost in the fourteen hoppers tested.

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Prior to mid-1958 the rods were located about 16 inches upstream of the charge length center. Since the reactor is primarily controlled with center rods 2, 5, 11, and 14, a general rear peaking condition would normally be expected. The rear side was, and still is skewed slightly to the front due to predominant rear rod usage. The metal was moved upstream to center the rod pattern and the front of the charge was then to the gun-barrel. It was expected that this would dampen the flux slightly due to the proximity of the gunbarrels but flux traverse data does not show that the low flux region extends throughout the entire front of the reactor.

If the ball drop of 11-8-59 gives any indication of what to expect regarding balls in the channels, one could deduce that unless gross distortions in the graphite have occurred in the past two years, many of the graphite voids were already filled. Very important to remember is the fact that although boron burnout occurs quite rapidly, Figure II, the steel remains and is appreciable when dealing with two or three hundred pounds.

Calculations estimating the reactivity worth of poisons are difficult. They are dependent upon the geometry of the poison and the regional flux, both of which can vary greatly and introduce large errors in the calculations. This must be remembered when numbers regarding ball worth are stated and corrections for geometry and flux made when necessary.

Any effect of the balls on reactivity was masked during the operating period in November because of the large change in residual pile exposure during the same period. Nevertheless, estimates of ball worth can be calculated, and a cost figure for compensating enrichment given. Since only the balls in the front of the reactor seem to be causing much trouble, only those channels shall be considered. The enrichment necessary to support the (approximately 160 pounds) balls in their present flux takes only about ten enrichment columns; however, to raise the flux so that it would approximate the normal cosine flux in the depressed region, some forty tubes worth of enrichment must be added. This is no contradiction, but rather an example showing that poison worth is dependent upon flux magnitude. The compensating enrichment would have to be charged in the region of the poison, perhaps two or three E-metal pieces located at about the 24-piece in the natural uranium charges; normal enrichment charging increases the peak.

From this analysis one can see that the cost of supporting the balls is not by itself too high, if the distortion they cause can be tolerated. The distortion, however, may be a source of ruptures and if this is true, the only solution is to add compensating or to rid the reactor of the poison.

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- (1) Final Report - R-84220 - "Removal of Stray Balls from VSR Channels at 105-D" - E. J. Filip, 12-17-57.

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Figure II

Poison burnout in balls as a function of time.

$$P/P_0 = \text{Poison/Initial Poison}$$

$$\text{where } \phi = 1.25 \times 10^{-13}$$

Months of Operation

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