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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DATE _____

Sept. 17, 1955

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AUTHOR

G. L. Wenger

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GENERAL ELECTRIC

RICHLAND, WASHINGTON

EM-45022

IRRADIATION PROCESSING DEPARTMENT

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September 17, 1956

A. R. Maguire, Manager
B and C Reactor Operation
IRRADIATIONS PROCESSING DEPARTMENT

C REACTOR POWER REDUCTION

Based on a study of C Reactor rupture experience discussed in this letter, and on the assumption that the 450 MWD/T goal is to be used as planned, it is recommended that an immediate reduction to a limiting tube outlet temperature of 85°C be made.

In the process of raising C Reactor goal exposures from low goal to the 450 MWD/T average goal which the Production Operation plans to use when an average goal of 500 MWD/T for all reactors is approved by the Commission, three side-hotspot type and two unclassified type ruptures occurred in July and August at exposures in the range of 387 to 489 MWD/T. This rupture experience afforded an opportunity to check the extrapolation to 450-500 MWD/T of much more extensive data (September, 1955 through February, 1956) at exposures below 280 MWD/T. In calculation of the recent rupture rates, all experience since June 1, 1956 on tubes with power factors from 1.0 to 1.2 was used. Most of the C pile tubes are in this power class. The following calculated table shows the number of tubes and ruptures involved:

Exposure Range MWD/T	No. of Tubes (factors > 1.0)	Summation of Tubes	Ruptures (factors > 1.0)	Cumulative Rupture Rate
165 - 204	161	2625	0	0.0
204 - 244	623	2464	3	0.0012
244 - 283	1481	1841	1	0.0067
283 - 322	41	360	0	
322 - 362	8	319	0	
362 - 401	88	311	1	0.0099
401 - 440	120	223	1	0.0144
440 - 480	83	103	1	0.0241
480 - 519	20	20	1	0.0741

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This recent experience agrees with the low exposure experience as shown by the attached figure. From consideration of the combination of all experience, we conclude that under the 450 MWD/T goal plan the average rupture rate for present maximum tube temperatures would with high certainty be between 0.015 and 0.035. This means that an average of two to three ruptures would very probably occur for every 100 tubes discharged. This would be an excessive rupture rate.

Based on all of this rupture rate data, maximum tube outlet temperatures calculated to give maximum production under the 450 MWD/T variable goal plan have been determined by use of the method of HW-44993 RD. This method was presented in the recent meeting. In the determination, doubling of the rupture rate by a 100 KW increase in tube power was used. We have considerable confidence that this number is not far from correct.

Two cases were considered. For one, a production lost time of 24 hours per rupture was used and for the other a 20 hour per rupture loss was used. For the 24 hour case, a maximum tube outlet temperature of 82°C is calculated to give optimized production. For the 20 hour case, a maximum tube outlet temperature of 83.7°C is calculated to give optimized production. An average of 3-4 ruptures per month would be expected at equilibrium, operating at about .70 production efficiency.

It should be noted that a substantial drop in production will be caused by the increase to the 450 MWD/T average goal in either of these cases or for any other limiting temperature used, assuming no improvement in metal quality. However, if the 450 MWD/T goal must be used, the results of the method show the way to make the best of the situation.

An approximate point of maximum production can be calculated in a more easily understandable manner than that of HW-44993 RD. By making some simplifying assumptions, the maximum tube outlet temperature at a point slightly past the point of maximum production for operation with a 450 MWD/T goal plan can be calculated arithmetically. The assumptions are as follows:

1. The inlet temperature is 18°C; the C Reactor operates at equilibrium with 1600 effective power tubes; the average central zone tube flow rate is 43.5 gpm.
2. The lost production per rupture is one day at full power.
3. All losses other than rupture losses are 15 percent of the equilibrium production for no ruptures. This assumption is not true and is the reason that this arithmetical method will show the point of production to be at a higher maximum tube outlet temperature than does the method of HW-44993 RD.

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4. The rupture rate is doubled by a 100 KW increase in tube power.
5. The rupture rate for conditions of assumption No. 1 and a 98°C maximum temperature is 0.026, as read from the attached figure.

Based on these assumptions, steps in calculating are as follows:

1. Select a maximum tube outlet temperature at which it is desired to find the production per month.
2. Calculate the rupture rate at the consequent maximum tube power using assumption No. 4.
3. Estimate a trial production in MWD/month.
4. Calculate the throughput in tubes per month for this production and for 450 MWD/T.
5. Multiply the tubes per month by the rupture rate to get ruptures per month which equals days loss per month.
6. Using assumption No. 3, the days loss, and the power level of the selected temperature, calculate the production in MWD per month. If this does not equal the trial production of step 3, repeat steps three through six until it does.
7. Calculate points at a sufficient number of temperatures to define the graph of production versus temperature, thus allowing the maximum production point to be found.

This procedure was used to calculate the following four points:

<u>Maximum Temperature</u>	<u>Production/Month</u> <u>MWD/Month</u>	<u>Ruptures/Month</u>	<u>Production Efficiency</u> <u>Percent</u>
98	22.4x10 ³	10.2	51.0
89	25.7x10 ³	5.75	65.8
85	26.1x10 ³	4.2	71.0
80	25.8x10 ³	2.81	75.6

From these points, it is evident that the point of maximum production is at a maximum tube outlet temperature near 85°C. It is also evident that between 80°C and 89°C, the production changes little, but above 89°C, production drops fairly rapidly. Thus, considering the chances that the rupture rate shown on the attached figure does not represent actual metal quality, the possible loss in production by making too small a temperature reduction is seen to be greater than the possible loss by making too large a reduction.

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The calculation of maximum production points above is for equilibrium metal-cycling on the 450 MWD/T plan. Also of interest is the schedule of expected ruptures. The situation can be discussed with aid of the following table:

PARTIAL C REACTOR LOADING ON 8-30-56, NUMBERS OF TUBES

<u>MWD/T</u> <u>Range</u>	<u>Tubes with Tube</u> <u>Factors > 1.0</u>
0 to 86	563
86 to 126	28
126 to 165	450
165 to 204	38
204 to 244	273
244 to 283	0
283 to 322	4
322 to 362	0
362 to 401	40
401 to 440	4

This table shows that a power reduction should be made at an early date. According to Production Operation plans, as of 9-12-56 tubes in the dotted box will largely be discharged for low g/t production. This is to be the last C Reactor discharge for low g/t product. Tubes below the solid line will largely proceed to the 450 MWD/T variable goal. Over 350 tubes are involved here. The bulk of them should average near goal around the middle of October. While the effect of varied specific power history is rather uncertain, an immediate power reduction may not produce a large reduction in rupture rate on these 350 tubes. Even with an immediate reduction to 85°C limiting temperature, these 350 tubes could very well produce five to nine ruptures before the end of October. Delay of one week before power reduction may result in about two additional ruptures.

The recommended reduction is to a point slightly above the calculated optimum. However, considering that there may be some error in the assumptions used and that the rupture data may possibly not represent correctly the quality of the present reactor slug loading, a somewhat conservative approach is indicated.

Manager, Research & Engineering
IRRADIATIONS PROCESSING DEPARTMENT

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