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TITLE

REZONING OF FRIDGE AT 105-KE REACTOR

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IRRADIATION PROCESSING DEPARTMENT

REZONING OF FRINGE AT 105-KE REACTOR

INTRODUCTION

A study was made to determine the optimum arrangement of the fringe flow zones at KE Reactor. Also considered, was the possibility of converting part or all of the existing fringe zone (actually three flow zones) from solid metal to I & E metal to decrease rupture potential in these low flow zones. The necessity for this study was indicated by high tube outlet temperatures in the fringe flow zones and the recent occurrence of two solid metal ruptures in process tubes located in the fringe zone of the reactor. Two additional solid ruptures occurred during the period that conversion to I & E in zone 2, as recommended below, was being completed.

RECOMMENDATIONS

1. Change the flow zones in KE Reactor as indicated in Figure 1. (1)
2. Extend the charging of I & E metal to include flow zone 2. (2)

- (1) Recommendation completed prior to issuance of this report.
- (2) Conversion from solid metal to I & E metal in flow zone 2 is presently being completed as metal is scheduled for discharge.

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DISCUSSION

The charging of K-III I & E metal has resulted in an increase in flow to the central zone process tubes (decrease in hydraulic resistance) and a decrease in flow to the fringe zone process tubes which remained charged with solid metal. Also higher reactor power levels together with a slight extension of the enrichment ring, to improve the number of effective central zone tubes, has increased the tube power in the fringe of the reactor. Rearrangement of the present flow zones can be done in such a manner as to provide a flow distribution which closely matches the power distribution in the reactor. A study of the power distribution at KE Reactor over the past five months indicates that if the reactor is rezoned as indicated in Figure 1 (assuming Zone 2 is charged with I & E metal) the flow in each zone will be proportional to the anticipated maximum tube power in each zone. In other words, the maximum tube outlet temperatures in each zone should be approximately equal. This data is summarized in the table below which indicates anticipated tube powers at a pile power of 3750 MW.

TABLE I

Zone	Per cent of average in a Zone 1 K-III metal charge	Per cent of Zone 1 tube power (avg. of highest 10 powered natural metal charges) 1500 KW base case
1	100 (62 gpm)	(1500) 100 down to 71
2	72 (44.5 gpm)	(1065) 71 down to 55
3	55 (34 gpm)	(825) 55 and down
4	51 (31.5 gpm)	55 and down

Examination of the above chart shows that the tube flows in Zones 3 and 4 are essentially equal and these zones can be considered as one for the purposes of rezoning. If solid metal is charged into Zone 2 the resulting Zone 2 flow will be 67 per cent (41.5 gpm) of the average flow in Zone 1 and the maximum outlet temperature will run approximately 4°C higher than the maximum natural metal charges in Zone 1.

A reduction in the rupture potential in the high powered fringe tubes can be accomplished by replacing the solid metal in these process tubes with less rupture prone I & E metal, but this must be done within economical limitations and in such a manner that it will not limit reactor power levels unnecessarily. For example, if a normal I & E metal charge is loaded into flow Zone 3 or 4 process tubes, operation with five high lifts, (normal operation is with six high lifts) in a case where one high lift is down for maintenance, would be impossible due to limitations imposed on these tubes by critical flow and trip after instability temperature limit considerations. (Reference: HW-59703, "Individual Process Tube Flow Protection Low Pressure Operation of K Reactors.")

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A study of the anticipated 100-K pump and reactor characteristics as affected in making these changes is summarized in Figure II. A study of this figure indicates that charging of process tubes in Zone 2 with I & E metal will increase total reactor flow from 180,800 gpm up to approximately 181,500 gpm, but it should be realized that the average flow in a Zone 1 process tube charged with natural I & E metal will be decreased by approximately 0.15 gpm due to a resulting reduction in riser pressure. This reduction in central zone process tube flow will be equivalent to a reduction in the rupture control point of approximately 10 kw per tube if a constant OSI⁽³⁾ is to be maintained on the basis of central zone tube powers. This reduction in the rupture control point is partially compensated for by an increase in the permissible total pile power level whenever the reactor is limited by bulk outlet temperature limits. Extending the charging of I & E metal as recommended will result in 14.5 per cent of the total number of the process tubes in KE Reactor containing solid metal.

A review of the various reactor tube outlet temperature limits indicates that the only temperature limit which will be reduced significantly by these recommendations is the Top-of-Annulus (TOA) boiling limit on process tubes charged with K-III natural metal in flow zone 2. Due to lower flow in Zone 2, these process tubes will have a TOA boiling limit 10°C lower than the comparable limit on process tubes⁽⁴⁾ in Zone 1. It is estimated that this limit, as calculated using the R value⁽⁴⁾ now specified by the Process Standards for limit determinations, will not restrict power level until the summer of 1961. The 1.2 R value now specified in Process Standards is believed to be quite conservative and very likely will be decreased during the next year, thereby increasing the TOA boiling limits. Therefore, the charging of I & E metal into flow zone 2 should not restrict pile power level, even on five-pump operation prior to Project CG-883 at which time complete conversion to I & E metal, projection slugs, or some other improved fuel element should be considered in conjunction with the necessary orifice changes. Also to be considered some time in 1962 is retubing of the K Reactors and the consequent effects this will have on tube geometry.

Some of the other factors of interest which will be affected by extending the charging of I & E metal into flow zone 2 (full evaluation of these was outside the scope of this study) are listed below:

1. Charge-discharge time will be decreased due to an increase in goal exposure on I & E metal.
2. Metal costs per MWD will be approximately equal, as with the present goal plans the higher cost per ton of I & E metal will be approximately offset

$$(3) \quad OSI = \frac{\text{tube power}^{3.3}}{1000} \times \frac{\text{tube outlet temperature}^{8.7}}{100}$$

- (4) The R value relates the temperature at the Top-of-Annulus in a process tube to the outlet temperature of a tube. This value is an important factor in determining the TOA boiling and TOA corrosion temperature limits.

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by operating the I & E metal to a higher exposure.

3. Enrichment requirements will be increased with I & E metal (approximately 12 additional charges of enrichment required).
4. The conversion ratio on I & E metal is slightly higher than for solid metal.
5. U^{235} burnout is higher with I & E metal due to operating the I & E metal to a higher exposure.
6. The Pu^{240} content is increased in I & E metal due to operating I & E metal to a higher exposure.
7. Increased flattening will be possible due to allowance for better distribution of heat in the fringe.

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ZONE MAP
K.E. REACTOR

SYMBOL	ZONE		ANTICIPATED TUBE POWER (PILE POWER OF 3750 MW)
	FROM	TO	
X	2	1	OVER 1065 KW
O	2	3	LESS THAN 825 KW
•	3	2	825 KW TO 1065 KW

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FIGURE 2

PUMP AND REACTOR CHARACTERISTIC CURVES

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