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C REACTOR REORIFICING ANALYSIS

INTRODUCTION

During the December 1953 extended outage the process water flow at C Reactor was increased and redistributed to allow reactor operation with a 69 tube enrichment ring in the third lattice unit and with the maximum protection afforded by the trip before boiling operational concept. The redistribution was accomplished by the installation of individual venturi flow meters on approximately 1800 process tubes. Flow and pressure requirements were met by the installation of larger diameter conventional Hanford orifices on about 200 tubes. During the outage, the original Panellit gages were replaced with improved Panellit gages equipped with long vane mercoid switches. (1)

The purpose of this memorandum is to review and report the results of the reorificing program and to compare them with predicted behavior.

SUMMARY AND CONCLUSIONS

The observed total flow rate of 82,200 gpm at an average front crossheader pressure of 385 psig, obtained initially following the reorificing, exactly checked the predicted value. The predicted Panellit pressures were attained within practical accuracy (about 15 psi) on more than 90 per cent of the gages installed, however, during the first week of operation following the startup from

(1) HW-28982, "Increased Reactor Safety Through Panellit Gage and Safety Circuit Revisions," R. O. Mehan.

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the extended outage anticipated film slough-off in fringe zone process tubes necessitated adjusting gage ranges on approximately 425 tubes. The gages requiring adjustment because of film slough-off were adjusted during reactor operation. No production losses were sustained due to scrams occurring while the gages were being adjusted.

It appears that a pumping cost saving of at least \$5000 per year will be realized due to lowered 190 pump discharge pressures even though approximately 10,000 gpm more water is now being pumped.

From tube boiling considerations it appears feasible to operate the reactor at an outlet temperature limit of 100 C on an annual basis.

The overall agreement between predicted and observed operating conditions indicated that the engineering methods which were employed were very reliable.

DISCUSSION

Predicted Operating Conditions

In order that previous central zone flow rates could be maintained the average central zone flow rate after reorificing was specified at 41.3 gpm. Theoretical calculations by McDaniels and Fullmer (2) after application of a 10 per cent safety factor to first and second lattice unit tubes dictated the following process tube flow rates with an enriched zone flow of 41.3 gpm.

<u>Position</u>	<u>Tube Flow Rate (gpm)</u>
3rd LU	41.3
2nd LU	38.6
1st LU	29.5

A 0.385 inch throat diameter venturi which delivers 41.3 gpm at a front crossheader pressure of 385 psig and a throat pressure of 224 psig, in an average C Reactor tube, was developed and was specified for the enriched or central orifice zone. This zone was extended to include second lattice unit tubes at the cost of supplying a theoretical surplus of 2.7 gpm through 172 tubes. Conventional 0.318 inch diameter orifices supplying 33.5 gpm at 385 psig front crossheader pressure were used in the outer orifice zone. The final orifice pattern is shown in Figure 1 on page 5.

At an average crossheader pressure of 385 psig, the predicted total flow rate was 82,200 gpm of which approximately 1150 gpm would be used in cooling the reactor shield and HSR's.

- (2) HW-29430, "Technical Aspects of Large Enrichment of C Pile," D. K. McDaniels and G. C. Fullmer.

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The average Panellit pressure was predicted at 220-225 psig. Calculations by IBM methods on a tube by tube basis were made and individual gage ranges for each tube were specified. Boiling limits high enough to allow reactor operation at tube outlet temperatures of 100 C throughout the year were attainable by narrowing the trip range to 60 psi.

Observed Operating Conditions After Reorificing

The observed total flow rate during reactor operation at an average front crossheader pressure of 385 psig was 82,200 gpm. The present average front crossheader pressure is about 368 psig and the total flow is 82,500 gpm.

The 190-C pump discharge pressures with nine pumps operating have been reduced from approximately 530 psig to 430 psig, while the total flow has been increased about 10,000 gpm. Reduced pumping costs are being realized and are estimated at at least \$5000 per year based on data available to date. Theoretical pumping cost savings are much greater than this, i.e. on the order of \$40,000 per year, and the cause of this difference is currently under active study by the Power Sub-Section.

Observed Panellit pressures have been in good agreement with predicted values. When the water pressure was initially raised to check Panellit pressure predictions, 162 or approximately eight per cent of the gages installed required pressure range adjustments of approximately 20 psi. A majority of the corrections however, were made in regions where reorificing increased the tube flow rates by 10-15 gpm. Based on changes that have been made since the original corrective changes were made it appears that film slough-off in fringe tubes began almost immediately. Since the startup approximately 425 gage range adjustments have been made. About 75 per cent of these changes were made during the first three days of operation.

For the most part all adjustments were completed in the first week. It appears that relatively stable film conditions have now been reached. It is of interest that all Panellit gage range adjustments which were required following startup were made during reactor operation and that no inadvertent scrams were caused during this process.

To date five Panellit scrams have occurred since the startup from the extended outage. Three of these scrams were attributed to low trips on either tube 2670-C or 2679-C, both tubes operating under provisions of "PT-105-519-E, Raising Permissible Outlet Temperatures of Selected Tubes at C Pile." On these gages it was possible to approach the low pressure trip without detection since at that time the gage dials had not been painted green in the low trip region. Two additional scrams were caused by regular tubes. The first occurred while the reactor was being shut down to discharge temporary poison and the second occurred during normal operation.

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Outlet temperature limits imposed by tube boiling considerations are high enough to allow operation at outlet temperature of 100 C at inlet temperatures from 5 to 20 C.

The overall agreement between predicted and observed operating conditions indicated that the engineering methods were reliable and that IBM tube by tube reorificing calculations are feasible for application to all reactors.

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- ☐ Central Zone - 0.385" Throat Diameter
Venturis. Average Flow Rate of 41.3 gpm.
- ☒ Outer Zone - 0.318" Diameter Orifices.
Average Flow Rate of 33.4 gpm.
- ☒ Special - Production Test 105-519-E.

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