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**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

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DOCUMENT NO.

HW-56269

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27

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TITLE

SYSTEM CURVES FOR 100-K WATER PLANT EXPANSION
PUMP ANALYSIS

AUTHOR

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SYSTEM CURVES FOR 100-K WATER PLANT EXPANSION
PUMP ANALYSIS

This document classified by:

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by

E. R. Rudock
 Reactor Modification Design
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MASTER

SYSTEM CURVES FOR 100-K WATER PLANT EXPANSION
PUMP ANALYSIS

INTRODUCTION

Modifications to the 100-K water plant will be made, under Project CG-775, to increase total process water flow rates to 175,000 gpm or greater. Included in the modifications will be the installation of new pump impellers for the primary and secondary process water pumps located in the 190-K Buildings.

The system curves in this report were developed to illustrate the adequacy of the proposed pump TDH curves for possible future reactor system changes.

CONCLUSIONS

It was found that with the proposed pumps:

1. With existing A1 process tubes and full pile loading of solid type fuel elements, flows greater than 170,000 gpm could not be obtained.
2. Flows of 175,000 and greater could be obtained for all combinations of central zone loading of I/E fuel elements with full pile aluminum process tubes or with central zone 40 mil wall zirconium tubes.
3. With full pile, 40 mil wall zirconium tube installations, all combinations of existing I/E sizes in central zone or full pile loadings would permit flows in excess of 190,000 gpm. However, flows greater than 190,000 gpm are beyond the proposed pump specifications for five pump operation

DISCUSSION OF CURVES

Assumptions

Central zone loading of I/E fuel elements in the K Area reactors is now in progress. However, the fuel element dimensions are still subject to development changes. A change in the fuel element will affect the pressure drop and flow through the process tube which, of course, changes the reactor system curves.

It was assumed that the new K size 8" I/E (1.474" O.D.) and the new C size 8" I/E (1.454" O.D.) would represent the largest and smallest dimensions of elements that would be considered for K use. The dimensions would lie between these dimensions.

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For a basis of calculation, it was assumed that the proposed future zirconium process tubes would be of uniform wall thickness and the tube would have only one horizontal center line, rather than the non-uniform wall and double horizontal center line used in the present aluminum tubes. Rib height was reduced 13 mils. It is realized that the zirconium tube, like the I/E fuel element, is in a stage of development

and the assumptions used above may not be the final tube dimensions; however, it was considered that the assumptions were conservative and would give high rather than low zirconium tube flow resistance characteristics.

The following combinations of system curves, shown on Figure No. 1, were developed:

POSSIBLE SYSTEM CURVES

Tube Inlet - 2°C, Tube Outlet - 110°C, Bulk Outlet - 95°C

<u>Curve No.</u>	<u>Process Tubes</u>		<u>Fuel Elements</u>	
	<u>Central Zone</u>	<u>Fringe Zone</u>	<u>Central Zone</u>	<u>Fringe Zone</u>
1	Al	Al	Solid	Solid
2	Al	Al	New K Size (1.474)	Solid
3	Al	Al	Present "C" Size (1.460")	Solid
4	Al	Al	New "C" Size (1.454)	Solid
5	Zr	Zr	Solid	Solid
6	Zr	Al	New "K" Size (1.474)	Solid
7	Zr	Al	New "C" Size (1.454)	Solid
8	Zr	Zr	New "K" Size (1.474)	Solid
9	Zr	Zr	New "C" Size (1.454)	Solid
10	Zr	Zr	New "K" Size (1.474)	New "K" Size (1.474)
11	Zr	Zr	New "C" Size (1.454)	New "C" Size (1.454)
12	Zr	Al	I/E with Flow Area Equal to Curve No. 2	Solid
13	Zr	Al	I/E with Annulus Equal to Curve No. 2	Solid

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DEVELOPMENT OF CURVES & DATA

Isothermal 189 D flow laboratory data exists only for the solid fuel element and the new "K" size (1.474") I/E element in a K aluminum process tube.

No data exists for the present "C" size (1.460) and the new "C" size (1.454) I/E element in a K Al tube. No data exists for a zirconium tube.

The following methods were used to develop curves to predict average reactor process tube pressure drop conditions:

1. Fuel element - process tube friction factors were calculated from the laboratory data for a solid and "K" size (1.474) element in an Al K tube, using Darcy's equation for pressure drop where the equivalent diameter was equal to four times the flow area divided by the total wetted perimeter. It was found that the average friction factor was significantly different for the I/E as compared to a solid.

These factors were checked with laboratory data for a "C" I/E in a C tube and the old K (1.498) I/E in a K tube. Calculated pressure drops agreed reasonably closely with laboratory measurements; therefore, it was concluded that friction factor, equivalent diameter and Darcy's equation method could be used to predict other fuel element and process tube combinations.

Laboratory data, used to determine the friction or shape correction factor was reported in document HW-54590 - "Standard Laboratory Hydraulic Pressure Drop Characteristics of Various Solid and I/E Fuel Elements" by E. D. Waters and G. R. Horn.

2. Laboratory data, corrected to equivalent reactor temperatures does not always agree, with the closeness desired, with data collected from the reactor. To correct for this difference, an average reactor ΔP curve, "Front Nozzle Barrel to Rear Header" taken from document HW-49012 "Effect of Outlet Water Temperature and Tube Corrosion on Hydraulic Demand Characteristics of Process Tubes" by J. F. Calkin was replotted for the same tube temperatures used in this report (56°C average) and used as a basis for calculating all other equivalent reactor fuel element pressure drops. These calculations were made by multiplying the solid element reactor data by the ratio of friction factors, equivalent diameters and the squared flow areas of the I/E elements and solid elements with aluminum or zirconium tubes.
3. A new total number of effective flow tubes was calculated for each case considered, using the existing orifice pattern and number of effective flow tubes as a basis. System head curves were then developed by summing reactor piping pressure drops and elevation differences.

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It is realized that the accuracy of the pressure drop curves is diminished by the number of corrections made, particularly in this case where an average reactor pressure drop was used as a basis. However, it is felt that this method will give more representative results than using temperature corrected laboratory data as a basis.

E. R. Rudock
Reactor Modification Design
PROCESS DESIGN OPERATION

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Total Pump & System Dynamic Head versus

Total Flow - From Five Pumps (Winter)
For Various Fuel Element Sizes

1,500

1,400

1,300

1,200

1,100

1,000

900

800

700

600

500

400

Total Dynamic Head - Feet

①

②

③

④

⑤

⑥

⑦

⑧

⑨

⑩

⑪

⑫

⑬

Al Tube - Full Pile Solid

Al Tube - Central New K Size I/E

Al Tube - Central C-Size 8" I/E

Al Tube - Central New C-Size I/E

Zr Tube Full Pile, Full Pile Solid

Zr Tube Center, Al Tube Fringe, Central New K I/E

Zr Tube Center, Al Tube Fringe, Central New C Size I/E

Zr Tube Full Pile, Central New K Size I/E

Zr Tube Full Pile, Central New C Size I/E

Zr Tube Full Pile, Full Pile New K Size I/E

Zr Tube Full Pile, Full Pile New C Size I/E

Zr Tube Center, Al Tube Fringe, Central I/E - Areas Equal to C Size I/E in Al Tube

Zr Tube Center, Al Tube Fringe, Central I/E - Areas Equal to C Size I/E in Al Tube

Zr Tube Center, Al Tube Fringe, Central I/E - Areas Equal to C Size I/E in Al Tube

Zr Tube Center, Al Tube Fringe, Central I/E - Areas Equal to C Size I/E in Al Tube

Zr Tube Center, Al Tube Fringe, Central I/E - Areas Equal to C Size I/E in Al Tube

Zr Tube Center, Al Tube Fringe, Central I/E - Areas Equal to C Size I/E in Al Tube

TOTAL FLOW - Thousands of Gallons per Minute

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