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REACTORS RELATED TO THE SHORT-RANGE WATER
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INTERIM FLOW INCREASES AT B, D, DR, F, AND H
REACTORS RELATED TO THE SHORT-RANGE WATER PLANT
MODIFICATION PROGRAM

May 5, 1961

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HW-69499
Page 2

May 5, 1961

INTERIM FLOW INCREASES AT B, D, DR, F, AND H
REACTORS RELATED TO THE SHORT-RANGE WATER PLANT
MODIFICATION PROGRAM

INTRODUCTION

It is anticipated that power levels for the old reactors will be restricted essentially by bulk outlet temperature limits from now until calendar years 1964 to 1966 when beneficial use from the plant process improvement program is expected⁽¹²⁾. Under these conditions, achievable power levels will be directly dependent upon total reactor flow rates. A program for achieving immediate reactor flow increases has been outlined⁽¹¹⁾ which will result in reactor flow rates consistent with current estimated water plant capacities this summer with the possible exception of H reactor. Methods for reducing the reactor hydraulic resistance and methods to permit increased thermal shield flow are under investigation in order that H reactor flows more nearly approach the current H water plant capacity this summer.

To provide flow increases in excess of the current water plant capacities at the old reactors, a short-range water plant modification program has been proposed by Facilities Engineering Section⁽⁹⁾⁽¹⁰⁾. The proposed program outlined by Facilities Engineering Section includes increased 181 and 183 building pumping capacity at B, D, and H areas, a new filter for F area, and larger impellers for the 190 building pumps at H area. It has been estimated that beneficial use for this proposed increased water plant capability can be obtained by the late fall of calendar year 1962 if prompt project approval can be obtained. In order to obtain an economic benefit from the proposed water plant capacity increases, methods of increasing flow through the reactor must be devised. Initially, various publications discussing this project inferred that rear Parker fitting reaming and installation of larger diameter rear-face pigtails were the only methods by which reactor flow increases could be economically justified. Hence, initially, acceptance of the short-range modification program appeared dependent on Parker fitting reaming and larger rear-face pigtails. Since the possibility of these two modifications will require further investigation, it is desirable to briefly explore alternate methods for increasing reactor flow so that the acceptance of the short-range water plant modification project proposal will not be unnecessarily delayed by these investigations. It is the purpose of this document to outline potential alternate methods for achieving reactor flow increases.

SUMMARY

A brief investigation of alternate methods for increasing reactor flow rates has been conducted in order to explore potential methods for utilizing the increased water plant capacities being proposed under the short-range modification program⁽⁹⁾⁽¹⁰⁾. The results of this investigation are plotted in Figures 1 through 5 and are shown in Tables I through III. Figures 1 through 5 depict current reactor hydraulic characteristic curves adjusted for currently planned changes in reactor hydraulic resistance and future reactor hydraulic characteristic curves which could be

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HW-69499

Page 3

obtained from these alternate changes. Currently planned changes in reactor hydraulic resistance include conversion to 32 piece O-III-NB charges, slight re-orificing in the fringe zone at some reactors, and installation of all helical inconel rear-face pigtails. Potential future hydraulic changes include reduction in fuel element size, reduction in fuel element charge length, enlarging rear face components, reorificing the fringe zones, and increasing the thermal shield flow (shown in Tables only). Tables Ia through III show methods of combining the individual flow increases available together in a conservative fashion to obtain total reactor flows which match the proposed increased water plant capacities. It is noteworthy that these methods do not necessarily include installation of larger rear-face pigtails and/or reaming of rear-face Parker fittings.

Selection of a final method by which the desired reactor flow increases can be obtained most economically will be the objective of studies which are now being started. Each method of increasing reactor flow investigated here has certain drawbacks which must be carefully investigated. For instance, enlarging rear-face components may have major effects on the mechanical integrity of the rear-face components. This is being investigated currently by members of Facilities Engineering Section.

Increasing the flow through the fringe zone and thermal shield will reduce the flow of the central zone tubes relative to the total flow and will have adverse effects on the rupture performance of the fuel elements (at the same bulk outlet temperature). Changes in the size of the fuel elements may have adverse effects on the fuel-element cost, rupture performance, and/or conversion ratio depending on the way the fuel elements are resized. These effects will be studied by members of Research and Engineering Section during the next six months so that the most economically attractive program for increasing reactor flow rates can be integrated into the short-range interim water plant modification program at that time.

In the interest of providing some immediate information for use in considering justification for the short-range interim water plant modification program, the flow increases that were obtained were based in some cases on incomplete data or on extensive simplifying assumptions. For this reason, the amount of the flow increases obtained were probably only accurate to around ± 10 per cent in all cases except in the increased fringe zone flow and increased thermal shield flow cases which may be in error by as much as a third and a half, respectively. Although these uncertainties may seem sizeable, considerable conservatism (20 to 30 per cent) has been factored into the use of these individual flow increase estimates. Thus, the resultant total flow increase estimates depicted in the accompanying tables are believed to be conservative. It is therefore considered highly probable that economically attractive methods of achieving reactor flow rates compatible with the short-range modification program are available.

DISCUSSION

A. Description of Investigation

1. General

Since bulk limited operation at the old reactors can be foreseen during

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HW-69499

Page 4

the next two or three years, it is desirable to initiate an immediate evaluation of methods for increasing reactor flow rates. Of particular interest at this time is an appraisal of methods which can be used to obtain reactor flow increases which will permit full utilization of the water plant capabilities proposed by the short-term modification program. There are several economically and technically attractive methods by which reactor flow increases can be made. Those investigated include the following:

- 1) A reduction in fuel element diameter.
- 2) Shortening of the fuel column charge length.
- 3) Reorificing of the reactor to obtain increased fringe zone flow.
- 4) Increased flow through the thermal shield.
- 5) Enlarged rear-face pigtails and nozzle fittings.
- 6) Enlarged rear-face pigtails, nozzle fittings, and crossheader Parker fittings.

The flow increases which may be obtained from each of the above items (except item 4) are illustrated in the accompanying figures showing reactor supply and demand curves for each reactor. In addition, the reactor flow increases necessary to reach the proposed water plant capacities are depicted in Tables Ia through III as combinations of the above items. It should be noted that the flow increases listed for particular items in the tables do not necessarily agree with flow increases depicted for the same items in the figures. It is intended that the tables provide a realistic illustration of the different approaches which can be used to match reactor flows with water plant capabilities. Since the calculations performed to obtain the flow increases were greatly simplified, the numbers obtained should be considered as estimates only. The numbers used in the tables were therefore reduced 20 per cent to 30 per cent below calculated values so that the combinations listed for attaining the desired flow rates are conservative and realistically possible.

2. Figures

Curves 1 through 4 on the figures depict present reactor hydraulic characteristics and the effects of currently planned changes such as slight reorificing, conversion to 32 piece O-III-NB fuel charges, and installation of all helical pigtails. These curves are drawn with solid lines, and curve 4, which is the present base case reactor demand curve adjusted for the currently planned changes listed above, is drawn with a heavy solid line. All proposed changes are applied to the curve 4 base case and are drawn as dotted lines. Four different adjustments in the fuel-element charge were shown. A three mil reduction in slug O.D. (with corresponding increases in slug I.D. to keep corrosion rates balanced) was illustrated because this change seemed feasible, at a cursory glance,

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HW-69499

Page 5

without incurring sizeable and continuing economic penalties due to major changes in fuel element manufacturing processes, fuel-element rupture characteristics, and/or reactor physics characteristics. Five and ten mil reductions were picked as changes drastic enough to cover the range of flow increases desired. Changes of this order will affect fuel-element manufacture, performance, and/or reactor economics to a larger degree (as discussed in more detail below) and will require a more thorough and longer program of economic evaluation and redesign. The flow increases available by reducing the charge length from a 32 to a 30 piece charge are shown as an illustration of the potential flow increases available from this source. No economic evaluation of this change was made. Changes in rear-face components are also depicted, so these flow increases can be easily compared with flow increases available from other sources. No increase in thermal shield flow is shown on the figures because this flow increase is not obtained by changes in the reactor hydraulic demand curve.

3. Tables

Three different basic assumptions were made in construction the tables. Table Ia and Ib were made assuming that there would be no change in the hydraulic characteristics of the rear-face components (i.e., the currently planned 5/8-inch inconel helical pigtails would be used and rear Parker fittings would not be reamed). In these cases flow increases were obtained with fuel element changes entailing either sizeable reductions in slug size or slight reductions in slug size combined with a shorter charge length. Table II assumed installation of 3/4-inch rear-face pigtails and 0.610 inch nozzle fittings but no other rear face changes. In this case a slight reduction in fuel element size was also assumed. Table III assumes installation of 3/4-inch rear-face pigtails, 0.610-inch nozzle fittings, and reaming of rear face Parker fittings from 0.469 inches to 0.610 inches. In this case no changes in fuel elements were assumed. In all tables the extra reactor flow increases needed to raise reactor flow rates to the projected water plant capacities were obtained from either or both fringe zone reorificing and increased thermal shield flow. These latter two methods of increasing reactor flow are inherently less desirable because the increased flow does not occur through the central portion of the reactor where the rupture stress is usually higher. Therefore, smaller flow increases similar to those listed in the tables would probably be utilized by these means. The optimum amount and proportion of each type of increase will, of course, be subject to revision based on future economic studies. The maximum flow increase available through the thermal shield was estimated at about 1000 gpm and the maximum reactor flow increase available by fringe zone reorificing was estimated at about 5000 gpm (except H which was about 2500 gpm). All flow increases for H reactor are based on the use of the larger 190 building process water pump impellers specified in the short-range water plant modification program.

B. Assumptions and Bases for Calculations

1. Temperatures

Where applicable in the calculations that were performed, a nominal tube

inlet temperature of 12°C was used and operation on bulk outlet temperature limits was assumed.

2. Bumper Slugs

Based on theoretical data a ~~1300~~¹³⁰⁰ gpm reduction in reactor flow was calculated as a result of converting the reactor completely from a non-bumper to a bumper fuel-element concept. At present, development is proceeding on a "tear drop" and a "button" type rail design which will reduce the total hydraulic resistance of the fuel element. Although no tests on these new designs have been performed, it can be assumed that a substantial portion of this flow loss could be recovered in the future if the new designs are successful. This potential gain was not depicted in either the figures or the tables.

3. Rear-Face Piping

Reactor flow changes resulting from changes in the rear-face piping were based on experimental data and were obtained from references (1) and (2). These calculations were based on conversion of the central 1600 tubes only.

4. Slug Changes

Those reactor flow increases developed by reducing the outside diameter of the slug and by shortening the charge length were based on theoretical and experimental data obtained from references (3) and (4). In each case it was assumed that the I.D. of the redesigned slugs would be increased so that the corrosion rates on the outside and inside surface of the slugs would be equal. In addition, these calculations were based on the current type bumper slugs which, with the present 1.445 inch O.D. and 0.310 I.D., do not have theoretically balanced corrosion rates.

5. Other Reactor Hydraulics

Hydraulic characteristics necessary for making other calculations to obtain current pump supply curves, future pump supply curve for H reactor, present operating conditions, predicted 1961 summer operating conditions, possible thermal shield flow increases, and maximum possible reactor flow increases from re-orificing were obtained from references (1), (4), (5), and (6).

6. Accuracy

In general, the data presented in this document should not be used with the accuracy that is implied by the construction of the graphs. Because of severe time limitations, as many analytical simplifications as possible were used. For instance, only one reactor demand curve was actually analytically determined (the B reactor present case). All future cases were calculated by determining the hydraulic difference between the B reactor present case and the future case in question, and these differences

were assumed to be additive and/or to apply to other reactors. In other instances where only one flow-TORP data point was known, reactor demand curves were compared to the B reactor present case and were drawn with the same curvature and approximately the same slope (at the same pressure the slope was arbitrarily increased slightly as the flow increased). Most of the hydraulic differences between the present and future cases were probably accurate to around ± 10 per cent. In the case where the reactor was reorificed to all venturis, the assumptions used to simplify this complex hydraulic change were less accurate so that the change obtained may be in error by as much as a third. The calculations made to obtain flow increases available through the thermal shield were based on incomplete data because of severe time limitations. Consequently, it is estimated that the 1000 gpm flow increased used throughout this document may be in error by as much as a half.

C. Limitations of Calculations and Other Economic Considerations

1. Slug Redesign

A reduction in average fuel element O.D. can be accomplished basically in three different ways. First, the average can wall thickness can be reduced without changing the core size or the guaranteed minimum can wall thickness. This will cause exponentially increasing fuel element costs beyond a three mil reduction in O.D. below the current O-III-N design because of the necessity for tighter allowable tolerances in the canning process. For instance, a five mil reduction in the current O-III-N O.D. would cause penetration test reject rate increases of five per cent to ten per cent. The cost of a fuel element would be increased by \$0.12 for a five per cent increase in reject rate⁽⁷⁾. Second, the average can wall thickness can be reduced without changing the core size, but the guaranteed minimum can wall thickness could be reduced the same amount. This will cause no increase in fuel-element costs (beyond nominal component and equipment changeover costs up to some point beyond consideration in this document) but this could cause some undetermined increase in the fuel element rupture rate. This will be particularly significant if most fuel element ruptures are occurring because of a uniform can wall corrosion rupture mechanism as is predicted for bumper fuel elements. Third, the average and guaranteed minimum can wall thickness can be maintained and the core size can be reduced. This will probably not cause any adverse changes in fuel element costs or rupture rates, but it will cause a reduction in the conversion ratio. This change was estimated at about one-half per cent for a ten mil reduction in the current core O.D.⁽⁸⁾. These economic effects are obvious, major deleterious ones which must be balanced against available reactor flow increases in order to obtain an optimum slug design. A more detailed examination of these effects and other effects on the fuel element manufacturing process must be made before an optimum slug redesign can be established.

2. Reorificing and Thermal Shield Flow Increases

A maximum reactor flow increase of roughly 5000 gpm (except for H reactor)

can be obtained by reorificing the fringe zones and an additional estimated 1000 gpm could be used in the thermal shield. This will result in a higher attainable reactor power level at a constant bulk outlet temperature; however, the tube outlet temperatures in the central zone will increase because there will be no change or a decrease in the flow of the central zone tubes. This temperature increase may be particularly significant in increasing rupture rates if uniform can wall corrosion rates are controlling fuel element performance; therefore, the extent to which these types of flow increases can be used to increase reactor power levels will depend on the rupture performance of the fuel elements. Since a change to bumper fuel elements is being made at this time and their rupture performance has not yet been established, an estimation of the economically justifiable degree of reorificing and/or increases in thermal shield flow cannot be made at this time. In addition, no detailed investigation of the thermal shield cooling system was conducted. A 1000 gpm increase was roughly estimated on the basis of the pressure drops through the system; however, there may be equipment considerations which will prohibit such flow increases or will make them economically unattractive.

3. Reduction in Charge Length

A reduction in charge length will cause an increase in specific slug power (at the same tube power) and will cause an increase in tube flow. These changes will have conflicting effects on the rupture rate which will have to be evaluated economically in order to determine the incentive, if any, for shortening the charge length.

4. Changes in Rear-Face Piping

Increases in reactor flow rates obtainable by enlarging rear-face piping were obtained from reference (1). The consequences of such changes in terms of the structural integrity of the rear-face piping is currently being determined by members of Facilities Engineering Section. The results of these studies will be the primary factors in determining the advisability of the proposed rear-face component changes.

5. Reactor Operating Limits

The effects of the proposed future changes on various operating limits was not investigated. Reductions in the reactor hydraulic demand as proposed in this document would cause a drop in front-header pressure (except at H where bigger impellers are proposed), an increase in rear-header pressure, and a subsequent drop in TAI limits. These effects will probably not be large enough to cause undue difficulty; however, if the drop in TAI limits is too great, the front-face venturis may have to be reamed. In addition, the effect of increased thermal shield flow on bulk outlet temperature limits was not investigated. The thermal shield is supplied by filtered water which does not have the same hydraulic transient characteristics as the process water supply. These transients are used in the calculation of bulk outlet temperature limits. For instance, since there are no flywheels on the filtered water pumps, the thermal

DECLASSIFIED

HW-69499

Page 9

shield flow will stop faster in an emergency. If the percentage of total flow supplied by the thermal shield is increased, the resulting increased bulk surge in an emergency may necessitate a lower bulk outlet temperature limit thus negating the economic advantage of the flow increase.

D. Program of Future Investigations

Although there are a number of limitations and inaccuracies inherent in the determination of each of the potential flow increases included in this brief study, there is not doubt that the water plant capacity increases proposed in the short-range modification program can be matched by reactor flow increases through some combination of the methods discussed in this document. In order to aid in determining the most desirable combination of methods for achieving the desired reactor flow increases, a more detailed program of investigation is being initiated and carried out as outlined below:

1. Members of Process Engineering Unit will work closely with members of Process and Reactor Development Sub-Section in optimizing the design of a smaller fuel element.
2. A study of the thermal shield coolant supply system will be made by members of Process Technology Sub-Section to determine feasible flow increases. This will include tests, hydraulic and equipment analyses by members of Process Engineering Unit, and an analysis of the effects of increased thermal shield flow on bulk outlet temperature limits by members of Process Analysis Unit.
3. A continual analysis of the rupture performance of bumper fuel elements will be made by members of Process Analysis Unit in the coming months. As the rupture characteristics and future performance of the bumper fuel elements becomes better defined, optimization studies by members of Process Engineering Unit to determine the most economically attractive flow increase through the fringe zones and thermal shield will be completed.

It is anticipated that the above studies will be completed in about six months and that, at that time, the results of these studies can be integrated with the results from studies being conducted by members of Facilities Engineering Section concerning the desirability of reaming rear Parker fittings and installation of 3/4-inch rear pigtails. A decision can then be made to determine, in general, the means for reducing reactor hydraulic resistance which can best complement the short-range water plant modification program and which can lead to final implementation of this program by the fall of CY-1962.

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HW-69499

Page 10

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DECLASSIFIED

HW-69499
Page 11

TABLE Ia

POTENTIAL FLOW INCREASES WITH CURRENT SIZE OUTLET FITTINGS, IN GPM

Condition	Reactor				
	<u>B</u>	<u>D</u>	<u>F</u>	<u>DR</u>	<u>H</u>
Base reactor flow (summer 1961 adjusted for 32 piece O-III-NB charge and helical pigtails - curve 4 in Figures).	87,000	86,900	86,700	84,700	85,000
Larger 190 Building impellers.*	---	---	---	---	3,000
Redesigned fuel element (5 mils OD reduction with corresponding ID increase for balanced corrosion).*	3,000	3,000	3,000	3,000	3,000
Current thermal shield flow.	1,000	1,000	1,100	1,200	1,200
Most economic flow increase either through the thermal shield or through the fringe zone to make total flow just equal water plant capacity.	<u>1,000</u>	<u>1,100</u>	<u>3,200</u>	<u>1,100</u>	<u>1,800</u>
TOTAL FLOW	92,000	92,000	94,000	90,000	94,000
Estimated capacity following interim water plant expansion.	92,000	92,000	94,000	90,000	94,000

* The flow increases listed for these items are only 70 per cent to 80 per cent of the increases shown for the same items on the Figures. This was done because the increases obtained were estimates subject to significant error; these tables are designed to give conservative and realistic examples of the methods that could be used to obtain the desired reactor flow increases.

TABLE IbPOTENTIAL FLOW INCREASES WITH CURRENT SIZE OUTLET FITTINGS, IN GPM

<u>Condition</u>	<u>Reactor</u>				
	<u>B</u>	<u>D</u>	<u>F</u>	<u>DR</u>	<u>H</u>
Base reactor flow (summer 1961 adjusted for 32 piece O-III-NB charge and helical pigtails - curve 4 in Figures).	87,000	86,900	86,700	84,700	85,000
Larger 190 Building impellers*.	---	---	---	---	3,000
Redesigned fuel element (3 mils OD reduction with corresponding ID increase for balanced corrosion).*	2,000	2,000	2,000	2,000	2,000
Reduction in charge length to 30 pieces.*	1,000	1,000	1,000	1,000	1,000
Current thermal shield flow.	1,000	1,000	1,000	1,200	1,200
Most economic flow increase either through the thermal shield or through the fringe zone to make total flow just equal water plant capacity.	<u>1,000</u>	<u>1,100</u>	<u>3,200</u>	<u>1,100</u>	<u>1,800</u>
TOTAL FLOW	92,000	92,000	94,000	90,000	94,000
Estimated capacity following interim water plant expansion.	92,000	92,000	94,000	90,000	94,000

* The flow increases listed for these items are only 70 per cent to 80 per cent of the increases shown for the same items on the Figures. This was done because the increases obtained were estimates subject to significant error; these tables are designed to give conservative and realistic examples of the methods that could be used to obtain the desired reactor flow increases.

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HW-69499
Page 13

TABLE II
POTENTIAL FLOW INCREASES WITH NOZZLE FITTING ENLARGED
TO 0.610" AND PIGTAIL ENLARGED TO 0.750"

<u>Condition</u>	<u>Reactor</u>				
	<u>B</u>	<u>D</u>	<u>F</u>	<u>DR</u>	<u>H</u>
Base reactor flow (summer 1961 adjusted for 32 piece O-III-NB charge and helical pigtails - curve 4 in Figures).	87,000	86,900	86,700	84,700	85,000
Larger 190 Building impellers.*	---	---	---	---	3,000
Nozzle fitting enlarged to 0.610" and pigtail enlarged to 0.750".*	1,200	1,200	1,200	1,200	1,200
Redesigned fuel element (3 mils OD reduction with corresponding ID increase for balanced corrosion).*	2,000	2,000	2,000	2,000	2,000
Current thermal shield flow.	1,000	1,000	1,100	1,200	1,200
Most economic flow increase either through the thermal shield or through the fringe zone to make total flow just equal water plant capacity	<u>800</u>	<u>900</u>	<u>3,000</u>	<u>900</u>	<u>1,600</u>
TOTAL FLOW	92,000	92,000	94,000	90,000	94,000
Estimated capacity following interim water plant expansion.	92,000	92,000	94,000	90,000	94,000

* The flow increases listed for these items are only 70 per cent to 80 per cent of the increases shown for the same items on the Figures. This was done because the increases obtained were estimates subject to significant error; these tables are designed to give conservative and realistic examples of the method that could be used to obtain the desired reactor flow increases.

TABLE III

POTENTIAL FLOW INCREASES WITH NOZZLE FITTING ENLARGED TO 0.610",
PIGTAIL ENLARGED TO 0.750", AND REAR PARKER FITTING ENLARGED TO 0.610"

<u>Condition</u>	<u>Reactor</u>				
	<u>B</u>	<u>D</u>	<u>F</u>	<u>DR</u>	<u>H</u>
Base reactor flow (summer 1961 adjusted for 32 piece O-III-NB charge and helical pigtails - curve 4 in Figures).	87,000	86,900	86,700	84,700	85,000
Larger 190 Building impellers.*	---	---	---	---	3,000
Nozzle fitting enlarged to 0.610", pigtails enlarged to 0.750", and rear Parker fitting enlarged to 0.610".*	2,700	2,700	2,700	2,700	1,200**
Reduction in charge length to 30 pieces.*	---	---	1,000	---	1,000
Current thermal shield flow.	1,000	1,000	1,100	1,200	1,200
Most economic flow increase either through the thermal shield or through the fringe zone to make total flow just equal water plant capacity.	<u>1,300</u>	<u>1,400</u>	<u>2,500</u>	<u>1,400</u>	<u>2,600</u>
TOTAL FLOW	92,000	92,000	94,000	90,000	94,000
Estimated capacity following interim water plant expansion.	92,000	92,000	94,000	90,000	94,000

* The flow increases listed for these items are only 70 per cent to 80 per cent of the increases shown for the same items on the figures. This was done because the increases obtained were estimates subject to significant error; these tables are designed to give conservative and realistic examples of the methods that could be used to obtain the desired reactor flow increases.

** The Parker fittings at H reactor can not be enlarged by currently planned methods because of their unique arrangement; hence, a flow increase is shown only for enlarged pigtails and nozzle fittings.

B REACTOR CHARACTERISTICS

LEGEND:

- ① Present
- ② Summer '41 (32 pc OIL charge except H which has F-N charge)
- ③ Adjusted for bumpers
- ④ Adjusted for all helical pigtail's - base case for future charges
- ⑤ With 2 mil reduction in slug 0.0 X
- ⑥ With 5 mil reduction in slug 0.0 X
- ⑦ With 10 mil reduction in slug 0.0 X
- ⑧ With 0.750" helical pigtail, 0.610" nipple fitting - ref. 1
- ⑨ With 0.750" helical pigtail, 0.610" nipple fitting, 0.610 parker fitting - ref. 1
- ⑩ With reduction to 30 pc charge
- ⑪ With nearsizing reactor to all venturi
- X With corresponding increase in slug ID to keep corrosion rates balanced (with bumpers)

B PUMPS

TOP OF RISER PRESSURE - PSI

REACTOR FLOW (WITHOUT THERMAL SHIELD) - G.P.M. $\times 10^{13}$

DECLASSIFIED

4/19/64

D REACTOR CHARACTERISTICS

LEGEND:

- ① Present
- ② Summer '61 (32 pc. OIII charge except H which has E-N charge)
- ③ ② Adjusted for bumpers
- ④ ③ Adjusted for all helical pigtails - base case for future charges
- ⑤ ④ with 3 mil reduction in slug O.D. *
- ⑥ ④ with 5 mil reduction in slug O.D. *
- ⑦ ③ with 10 mil reduction in slug O.D. *
- ⑧ ④ with 0.750" helical pigtail & 0.610" nozzle fitting - ref. 1
- ⑨ ④ with 0.750" helical pigtail, 0.610" nozzle fitting, & 0.610" parker fitting - ref. 1
- ⑩ ④ with reduction to 30 pc. charge
- ⑪ ④ with reorificing reactor to all venturi
- X with corresponding increase in slug I.D. to keep corrosion rates balanced. (with bumpers)

TOP OF RISER PRESSURE - PSI

REACTOR FLOW (WITHOUT THERMAL SHIELD) - GPM $\times 10^{-3}$

DECLASSIFIED

4/19/61

DR REACTOR CHARACTERISTICS

LEGEND:

- ① Present
- ② Summer '61 (32 pc OTM charge except H which has E-N charge)
- ③ ② Adjusted for bumpers
- ④ ③ Adjusted for all helical pigtails - base case for future changes
- ⑤ ① with 3 mil reduction in slug O.D. *
- ⑥ ④ with 5 mil reduction in slug O.D. *
- ⑦ ③ with 10 mil reduction in slug O.D. *
- ⑧ ④ with 0.750" helical pigtail, 0.610" nozzle fitting - ref. 1
- ⑨ ④ with 0.750" helical pigtail, 0.610" nozzle fitting, 0.610" parker fitting - ref. 1
- ⑩ ④ with reduction to 30 pc. charge
- ⑪ ④ with reorificing reactor to all venturi
- * with corresponding increase in slug I.D. to keep corrosion rates balanced (with bumpers)

TOP OF RISER PRESSURE - PSI

640
630
620
610
600
590
580
570
560
550
540
530
520
510
500

80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

REACTOR FLOW (WITHOUT THERMAL SHIELD) - GPM $\times 10^{-3}$

8 PUMPS

DECLASSIFIED

4/19/61

A REACTOR CHARACTERISTICS

LEGEND

- ① Present
- ② Summer 'N (32 pc OIL charge except H which has E-N charge)
- ③ Adjusted for bumpers
- ④ Adjusted for all helical pigtails - base case for future charges
- ⑤ With 5 mil reduction in slug O.D. X
- ⑥ With 5 mil reduction in slug O.D. X
- ⑦ With 5 mil reduction in slug O.D. X
- ⑧ With 0.150" helical pigtail, 0.610" nozzle fitting - ref. 1
- ⑨ With 0.150" helical pigtail, 0.610" nozzle fitting - 0.610" parker fitting - ref. 1
- ⑩ With reduction to 30 pc charge
- ⑪ With reorienting reactor to all venturi
- ⑫ X with corresponding increase in slug I.D. to keep corrosion rates balanced (with bumpers)

TOP OF RISER PRESSURE - PSI

8 pumps

REACTOR FLOW (WITHOUT THERMAL SHIELD) - GPM X 10³

DECLASSIFIED

11/19/64

11 Reactor (WIRREACTOR)

[illegible]

SAHJEDINI PI
KALAM KALAM

[illegible][illegible]

REACTOR FLOW (W/O THERMAL SHIELD) = $61.0 \text{ MW} \times 10^{-3}$

19/10/13

001 66 86 76 96 86 76 66 76 76 76 68 88 48 37 54 48 68 78 78 68

[illegible]

DECLASSIFIED

66-67-MH

DATE
FILMED

6/15/94

END