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REACTOR MODIFICATIONS FOR INTERIM FLOW INCREASES

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STUDY PROGRAM

REACTOR MODIFICATIONS FOR INTERIM FLOW INCREASES

June 1, 1961

by

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STUDY PROGRAMREACTOR MODIFICATIONS FOR INTERIM FLOW INCREASESI. INTRODUCTION

Plans are currently under way to supplement the capacity of the B, D, DR, F and H Reactor water plants on an interim basis⁽¹⁾. Utilization of this expected flow can be achieved in a variety of ways, and the choice of optimum approach will be made as a result of engineering studies and tests now under way. The potential production gains possible from full utilization of the proposed water plant flow increases is a strong incentive to develop the alternative possibilities to the point where an integrated plant approach can be timed to coordinate with the availability of water from the new facilities.

It is the purpose of this document to examine the alternatives and describe the study program aimed at developing the optimum interim solution. Benefits obtained through modification of reactor components and/or reactor loadings will be expected to provide a short-term (one year) pay-out. This should permit liquidation of the costs prior to start of the Major Plant Improvement Program for the older reactors, tentatively scheduled to begin in FY-1964. Major piping replacement or work requiring extended reactor outages is, therefore, not considered.

II. SUMMARY

Current studies of the potential means for utilizing the additional water expected from Interim Water Plant modifications indicate that several approaches are possible. This review has shown that a minimum of 5000 gpm per reactor flow increase can be accomplished through potential fuel loading changes. Alternatively, relatively minor modifications to rear-face piping predicted from laboratory data can result in a reduction in reactor resistance sufficient to permit from a 3000 to 5000 gpm per reactor flow increase. Programs now planned or under way are expected to indicate the optimum choice of methods to maximize economic production gains, and are discussed in a preliminary form in the discussion below. Progress of the various related phases is planned to permit a decision of the preferred course of action by March, 1962.

A Program Integration Chart has been prepared to show the interrelation of this work and is part of this report. The chart shows a breakdown of the work planned at this date, and current scheduling for the entire program, both for providing and for utilizing interim flow increases at 105-B,D, DR, F, and H. The work shown can be grouped into these categories:

(1) HW-66954 (SECRET), "Short-Range Modification Program for Increased Productivity", L.B. Brinkman and V.G. Blanchette, dated January 12, 1961, and HW-66954 ADD dated April 24, 1961.

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- a. Water Plant Modifications
- b. Optimization of Fuel Loadings
- c. Downcomer Piping Flow Capability
- d. Crossheader Expansion Joints
- e. Improved Rear-Face Connectors
- f. Parker Fitting Inspection, Repair and Modification

Beneficial use of the increased water plant capacity can be achieved during the First and Second Quarters of FY-1963, although full utilization may require two or three months additional time if new rear-face connectors are desired.

III. FLOW CAPABILITIES

The following Table I (taken from reference 2) shows through-reactor flows expected before the end of 1961 at each reactor, as well as water plant capacities before and after the Interim Water Plant Increase proposal(1). It can be seen that reactor and water plant flow capacities will be rather well matched by the end of the year except in H Area where excess water plant capacity will still exist. Reactor flow increases will be achieved primarily by going to the O-III-N fuel element (1.445 in. nominal O.D. vs. the 1.452 in. currently experienced with the O-II-N), and by shortening the charge length to 32 pieces (vs. 34) in B, D, and F Reactors. Lesser gains will be achieved by re-orificing fringe tubes where feasible. Experience to date with O-III-N fuel loadings indicates that still larger flows will be achieved at DR and F at least until bumper fuel elements are loaded into these reactors.

TABLE I
REACTOR & WATER PLANT FLOW CAPABILITIES

	<u>B</u>	<u>D*</u>	<u>DR*</u>	<u>F</u>	<u>H</u>
<u>1-1-61</u>					
Reactor Flow	85,000	84,900	83,500	86,700	86,300
Expected Reactor Flow** 1961	87,000	87,300	85,600	89,000	86,400
Current Water Plant Capacity	87,000	88,000	86,000	89,000***	91,000
Interim Water Plant Program	92,000	92,000	92,000	94,000	94,000

* Division between the two reactors can be varied somewhat within the total shown.

** Limited by water plant capacity except at H Area

*** Limited by filter capacity.

(2) HW-68722 (SECRET), "Proposed Program for Nominal Reactor Flow Increases", S.M. Graves, dated March 2, 1961.

As increased water plant capacity is made available by beneficial use of the equipment proposed in Interim Water Plant Modifications, this capacity would be effectively utilized by an optimized combination reduction of fuel charge resistance, improved flow distribution, or reduction of rear-face hydraulic resistance. These alternatives are described below:

1. Reducing Fuel Charge Resistance⁽³⁾

- a. Further reduction in slug diameter: A further reduction in the O-III-N slug O.D. from a nominal 1.445 is possible. Production gains would have to be balanced against higher fuel costs (due to higher reject rate), greater rupture frequency (if wall thickness were reduced), or lower conversion ratio (if core size were reduced).

Flow increases of 2500 gpm and up would be possible over the expected reactor flow with O-III-NB loadings.

- b. Further shortening of charge length: Reduction to a 30-piece charge should permit a flow increase of up to 1500 gpm with O-III-NB slugs.
- c. Improved slug design: Further development of the O-III-NB slug design may provide reduced flow resistance sufficient for a flow increase of up to 500 gpm per reactor.

2. Increasing Over-all Reactor Flow

- a. Replace fringe zone orifices with venturis: Complete orifice replacement would permit up to 1000 gpm additional total reactor flow. The proper loading pattern to prevent excessive flow reduction in the critical zone tubes has not been developed.
- b. Increase Shield Flow: Increases in thermal shield flows of up to 1500 gpm are possible immediately, and would theoretically permit an equivalent increase in power level when the reactors are operating on bulk temperature limits. This scheme is based on the same principle as previous quenching proposals. To take advantage of this would require return of the shield flow to the process tube flow far enough upstream from the downcomer to obtain adequate mixing.
- c. Install higher head impellers in 190 Building Pumps: New impellers in existing 190 Pumps may afford an attractive alternate to reducing hydraulic resistance of the reactor with flow increases of 3,000 to 4,000 gpm per reactor possible without exceeding horsepower limitations. The previous tests run during acceptance of the De Laval pumps, plus additional design study indicates that higher head impellers are feasible.

(3) HW-69322 (SECRET), "Interim Flow Increases at B, D, DR, F and H Reactors", J. L. Benson, dated April 26, 1961.

Similar installations can be made available for the other reactors if additional reactor flow beyond present planning is desired. Delays in obtaining production benefits from the increased water plant capacities could result, however, from using this approach alone due to the time element in obtaining appropriate electrical capacity increases.

3. Reducing Rear-Face Hydraulic Resistance

- a. Install larger rear-face connectors: The existing 5/8" O.D. connectors, especially the closed helical type, are a major source of hydraulic resistance in the rear-face piping. Flow increases of up to 2000 gpm⁽⁴⁾ are available by substituting 3/4" O.D. connectors and enlarged nozzle fittings. These may be procured and installed individually if desired without rear-face work other than disassembly and reassembly. Any problems in other portions of the rear-face piping would not be improved; other work would, therefore, still be desirable to minimize rear-face stresses from increased vibration.
- b. Enlarge crossheader Parker Fitting diameter: The location of the largest pressure drop in the rear-face piping and an apparent source of cavitation and resultant high frequency vibration is the restricted passage in the crossheader Parker fitting. Critical flow has been shown to exist at this point, and evidence of cavitation has been observed at some fittings. Laboratory tests have shown that flow increases of 2000 to 3000 gpm per reactor would be possible if this opening can be enlarged from the present 0.469 inches to about 0.610 inches. A combination of the larger connectors with these enlarged fittings would provide a total flow increase of 3000 to 4000 gpm per reactor at B, D, DR, and F Reactors. This method is not applicable to H Reactor because of the elbow between the fitting and the crossheader.
4. Methods 1a, b, c and 2 a, b listed above will require laboratory studies and economic optimization studies. This work will not be discussed further in this document as the action responsibility lies with other components. Methods 2 c and 3 a, b will require further engineering studies under Facilities Engineering Section responsibility and are discussed in more detail in following sections.

Figure 1 shows the reactor process supply curves used and representative demand or system curves. Fitting sizes and change designations for the examples shown are listed in Table A-I of the Appendix. Supply curves for B,

(4) Author's calculations from unpublished test data obtained from P.A. Carlson.

D, DR, and F Reactors were drawn from two or more actual operating points. The supply curve used for H Reactor is drawn from the original pump test curve⁽⁵⁾ as only one operating point is available to date. The slope of the curve is seen to differ from the D and F Reactor supply curve even though the pumps are presumably identical. The slightly lower pressure loss between 190 pump discharge and top of riser accounts for only part of this difference, so that the absolute values for H Reactor under future conditions may be somewhat optimistic.

Figure 2 shows calculated pressure profiles for D or F Reactors for several possible cases. For each case, the pressure drop across the header fitting was obtained by subtraction and should be substantiated by further flow tests. The rear crossheader pressure shown is a minimum and represents the worst condition for critical flow. It is indicated that critical flow will persist in many crossheader fittings with increased flow with either size connector unless the header fittings are enlarged beyond 0.610 inches I.D., although the number affected would be considerably less with the smaller connector. With larger connectors, a sizeable increase in pressure drop across the header fitting will occur unless the fitting I.D. is increased to about 0.650 inches. The significance of this increase in terms of cavitation damage will require further testing. Pressure drops would not be greatly changed from the present with only a change in the hydraulic resistance across the active change.

IV. POTENTIAL PROBLEM AREAS AND PRESENT STATUS

A. Rear-Face Connectors

As a replacement for the original duPont helical connectors which were failing at an increasing rate, rear-face connectors of the J type were designed and introduced in the fall of 1958. They have been used only as needed replacements except at H Reactor where about 1500 of these units were installed. There has been a total of about 4600 in use at the five older reactors. These connectors facilitate maintenance access to the rear-face piping complex and provide some reduction in flow resistance, but are subject to binding and ratcheting effects from misalignment, O-ring seal leaks from material deterioration, tubing distortion from excessive strains, and they increase cyclic stress on the Parker (header) Fitting through the cantilever effect of the rigid adapter sleeves.

Metallurgical examinations of Zyglo-processed helical rear-face connector samples from each of the older reactors were made in the fall of 1959. Stress cracks of potential rupture severity were found in 30 to 60 percent of these samples. The J-type connectors with about one year of reactor service showed stress cracks in 30 to 40 percent of the samples. The J-type connector was, however, found to be an acceptable interim

(5) HW-60643 (Uncl.), "DG-558 Performance Test - 190 Building Pump with Replacement Rotating Assembly", N.F. Fifer, dated June 5, 1959.

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replacement unit for a period not to exceed a proposed one-year service span. Development effort was then initiated for a new connector design which would not only provide a longer service life, but would also show improved hydraulic and mechanical characteristics.

The J-type connectors generally have provided the estimated 12 months of reactor service, but have been failing at an accelerated rate, particularly at 105-H Reactor. In November, 1960, therefore, the Facilities Engineering Section recommended that J-type connector procurement be stopped, and that an open-helix Inconel connector be used as a replacement component until an improved connector could be tested and made available for reactor application.

Several factors were considered in recommending the open-helix Inconel connector, aside from the need for a more serviceable unit. The originally installed close-helical rear-face connectors (pigtails) provided extended reactor service with a minimum of connector maintenance. There were several undesirable features such as: (1) Difficulty in starting threads, (2) Lack of access to other components, (3) Excessive time of installation. Even so, this type of connector provided longer periods of trouble-free service than has been experienced with later models. The open-helix design will tend to minimize the three objections listed above, although it will not eliminate these undesirable features. A metallurgical shortcoming of the original helical connectors was the susceptibility of the 304 stainless steel tubing to stress corrosion, a factor which was a major contributor to their eventual failure. The recommended alloy (Inconel) shows no tendency toward stress corrosion. The first of these Inconel connectors have now arrived on plant and are currently undergoing testing.

Preliminary design is also in progress on an application tool to aid in the alignment and shaping of these helical-type connectors during installation.

Substitution of a flexible connector would tend to minimize the possibility of corrosion fatigue and stress cracking in the connectors and fittings, eliminate make-up and thermal stresses, and simplify maintenance in this area. Flexible type rear-face connectors are being developed; preliminary samples for testing were recently received from the fabricator, but test results were unsatisfactory. Additional samples and further laboratory flow and vibration susceptibility tests would be necessary before approved reactor testing could be initiated.

The present region of maximum controllable flow resistance in the reactor piping components occurs between the rear-face nozzle and crossheader. Enlargement of the connector tubing would permit increased reactor flow, but poses several engineering problems, since rear-face piping presents a rather involved complex which does not permit the ready modification of an individual component. A larger (3/4 inch O.D.) connector has been designed and is on order for testing. Several wall thicknesses in both Inconel and aluminum alloys are being procured in order to determine the optimum combination of service life, flexibility, hydraulic characteristics, and cost. An enlarged nozzle fitting and an adaptor for

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attaching the 3/4 inch connectors to the existing crossheader fittings have also been designed and are being procured for testing. Figure 3 (SK-1-4791) shows the current connector design.

B. Rear-Face Crossheader Fittings

Laboratory data⁽⁶⁾ show that the principal flow restriction of existing rear-face piping occurs in the fitting and connector adaptor at the rear-face crossheader. Enlargement of these passage restrictions is a direct step toward obtaining increased process water flow. However, successful modifications of this type will require continued serviceability and leak-tightness of the modified fittings.

A total of nine failures of crossheader Parker fittings have been reported to date. One of these was in the weld to the crossheader, the remainder in the threaded area. The latter have been attributed to a combination of stress corrosion and fatigue cracking⁽⁷⁾. Extensive inspection and testing will be required to determine if the reported failures are symptomatic of accelerated failure, and if modification can be accomplished in such a way as to avoid accelerated failure. Removal of selected fittings for thorough metallurgical examination must be part of this evaluation process. Plant Engineering is currently investigating the availability of instruments and is formalizing a non-destructive test program to determine the integrity of the installed crossheader Parker Fittings and of the fitting to crossheader weldments. Development is also in progress on methods of sample procurement and subsequent piping repair to obtain a number of installed Parker rear-face crossheader fittings for metallographic and mechanical laboratory evaluation. Work to date indicates that samples can be successfully obtained by either trepanning or by sectioning of the crossheader. Repair methods for both techniques require further development, but appear to be practicable. The development of tool designs and application techniques is being pursued to provide improved fitting enlargement methods if required.

In preparation for the possibility that a certain number of fittings may be damaged during enlargement and require repair, as well as in support of the current reactor need, development of improved fitting repair methods is proceeding with high priority. Repairs involving direct welding to the crossheader are undesirable because of the excessive risk of unrelieved weld stresses and sensitization of the stainless steel. Development is, therefore, proceeding along two lines, a temporary quick repair based on the use of a bolted-on service saddle and gasket, and a more permanent repair based on threaded fittings. Figure 4 (SK-1-4735) shows one proposed temporary repair.

- (6) HW-65756-1 (Conf-Undoc), "Laboratory Determination of Normal Operating Flow Rates with Enlarged Outlet Fittings, B,D,F Reactors," E.D. Waters, dated February 2, 1960.
- (7) J. H. Hoage, personal communication.

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C. Rear-Face Crossheaders

Extensive studies have indicated that two of the major detriments to the integrity of rear-face piping for either present or interim flow increase service are:

1. Over-stress of crossheader elbows and riser connections caused by thermal expansion of the headers.
2. Excessive low frequency vibration of crossheaders during normal reactor operation.

Substantially increased temperatures over original design criteria cause excessive thermal expansion of rear-face piping. As a result, high stress levels exist at the ends of the crossheaders and the crossheaders bow upward in the center. The latter condition makes the headers receptive to low frequency vibration excitation from the hydraulic system by creating a long unsupported span. The vibration in turn plays a definite part in the failure of rear connectors, Parker fittings and, in some cases, the crossheader itself at the junction with the riser.

Restraining the headers to prevent bowing up off the supports will control the low frequency vibration. This move alone would be unwise, however, because it would increase the stress at the ends of the headers by forcing all expansion to be absorbed there. Thus, it is apparent that some type of expansion joint must be inserted in the crossheaders in conjunction with crossheader restraint.

Specifically, it has been proposed that a flexible joint be installed at each end of the rear crossheaders and that the crossheaders be restrained with suitable guides and anchors to reduce stress levels at the ends of the crossheaders and to control the low frequency, high amplitude cross-header vibration. Figure 5 (H-1-12767) shows the general layout of the proposed installation authorized on Production Test IP-356-AE⁽⁸⁾.

Three types of flexible joints are currently being considered. They are:

1. Hycar hose.
2. Two Dresser couplings with a spool piece between them.
3. An all metallic, bellows type joints.

A prototypic installation of a set of Dresser coupling type joints and appropriate crossheader restraints on No. 25 rear-header at H Reactor was accomplished on March 9, 1961. Preliminary study of the data obtained following this installation indicates a factor of about two reduction in low frequency vibration and a factor of about three reduction in strain at the riser-crossheader connection. To date, the joints show no evidence of deterioration or leaking.

(8) HW-6665C (Uncl) "Production Test Authorization PT-IP-356-AE, Rear Cross-header Expansion Joints", by O.E. Adams, J.H. Hoage, and P.H. Hutton, dated September 14, 1960.

Further testing is necessary to determine the most effective and durable joint for this service. Arrangements have been made for prototype installations of Hycar hose joints at H Reactor and Dresser coupling and metallic bellows joints at DR Reactor. These multiple installations will accelerate determination of the optimum type of joint to be considered for full-scale installation.

D. Crossover Line and Downcomer

Reactor flow capabilities are not at present affected by minor changes in pressure drop from the crossheader through the risers and crossover line. This is so only because critical flow exists in the crossheader fittings, making flow independent of downstream pressures (below some critical pressure). If fitting throat diameters are increased sufficiently to eliminate critical flow conditions, this will no longer be true. Under such conditions, a pressure increase of 5 psi would reduce reactor flow by about 1000 gpm.

Two-phase flow is believed to exist at present in the downcomer approach piping at all reactors, as evidenced by pressure measurements taken as part of the DR bulk limit test program and non-representative downcomer model studies at Washington State University.

Although more sensitive to temperature increases in the present operating region, pressure losses in this portion of the rear-face piping will increase to some degree with increased flow. Unstable flow characteristics are also possible. Since the pressure drop is not readily susceptible to extrapolation, further investigation is required before assurance of expected production gains can be had. A model test program, now in process of negotiation, is expected either to provide such assurance or to provide recommendations for any modifications to existing piping systems that may be required.

A related condition may arise, as a result of increased flows, in excessive steam emission from downcomer or effluent line vents. Investigation of this problem is also planned as part of the model program referred to above. Within limits of steam quantity, additions to the vent systems could be provided, although additional costs would, of course, be involved. Some consideration of slight pressurization will also be given as an alternative course of action.

Excessive vibration has been previously reported on the downcomer approach piping at 105-H. Initial measurements indicate low frequency--high amplitude vibration which shows some correlation with hydraulic pressure disturbances. Further study of this piping is required to better define the problem and a remedy.

V. PROGRAM SCHEDULE

Figure 6 is a Program Integration Chart which illustrates the relationship of the various elements contributing to the general flow increase program. It may be noted that, unlike the usual procedure with such a diagram, no critical path is shown. It has not been done in this case since beneficial use of the water plant for each reactor is not only independent of the others,

but also is not fixed by the other work shown if further changes in fuel loading prove to be economically attractive. Choice of alternatives permits several routes leading to beneficial use of new water plant components.

In general, the timing shown on the Integration Chart is optimistic, not so much in the time required to perform certain steps as in the assumption used throughout that each development step will show early success. In some instances, an error in this assumption would not affect the over-all timing; in others it could, as for example on reactor tests of new connectors, or removal of sample fittings from the reactor.

Inspection of the chart will show that the over-all program shown is made up of five main divisions of effort.

1. Water Plant Modifications - Starting Work Block No. 4

Description of the work required and the work schedule for this phase is discussed in more detail in Reference (1). Nearly every step in the work flow is critical in terms of beneficial use at one or all reactors. As shown, project completion and beneficial use is expected to be phased in during the Fourth Quarter of CY-1962. Since this is more or less normal construction effort, the usual procedures and schedules would apply. The starting date of April 1 remains realistic in view of the current status of the proposed work program outlined in the chart.

2. Optimization of Fuel Loadings and Flow Studies - Starting Blocks No. 6, No. 8 and No. 22.

Fuel optimization is to be done by other components and is not part of this development program. It is shown, however, since the results of the work will be required before final justification for rear-face fitting modification can be determined.

Flow studies, both theoretical and with a scale model of the D Downcomer approach piping, are required to determine the maximum flow increase that can be recommended as a result of increasing hydraulic resistance in the downcomer approach or increased pressures in the downcomer. The need for additional downcomer venting or simple piping improvement will also be looked for. Although the piping chosen for the model test is typical only of B and D Reactors, flow limitations so determined should be conservative for DR, F and H Reactors. Static flow testing is expected to be completed in July, but for assessing reactor safety aspects, some additional transient flow investigations will be desirable and will require additional time.

3. Crossheader Expansion Joints - Starting Block No. 5

As discussed in a previous section, the need for crossheader modification exists now and is independent of flow increases. Greatly significant flow increases can only worsen the existing situation. Since it is currently planned to propose installation of expansion joints starting in FY-1962, the benefits provided by this equipment can be utilized as increased flows are available.

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4. Rear-Face Connectors - Starting Block No. 17

Provision of improved connectors is, as discussed earlier, a desirable improvement. Earlier in this study it appeared that enlarged connectors would be required for full use of the increased water plant capacity. At present, as pointed out above, additional fuel loading modifications are considered as a potential alternate. In addition, improved designs such as flexible connectors, or other materials such as aluminum, may prove to possess other advantages of cost or performance. In order to make an informed decision, testing of 3/4 inch aluminum open-helix connectors is proposed, including on-reactor testing following initial laboratory tests. Design of initial specimens is complete and procurement of samples is in progress. On the assumption that laboratory testing of these specimens will be favorable, a production test (Block No. 3) involving complete modification of an existing crossheader, including expansion joints, larger connectors, and enlarged crossheader fittings, is proposed for demonstration of hydraulic and vibration behavior. The time schedule shown will probably not permit a complete evaluation (Block No. 28) of expected connector life prior to the decision Block No. 34. Data expected from the testing include flow increase and pressure profile changes, evidence of changing vibration measurements and cavitation characteristics, changes in stress in header fittings, leak-tightness, and maintenance convenience. The installation will also serve as a demonstration of current design of tools and techniques for enlarging header fittings.

Continued on-reactor testing of various connector designs will be required for selection of the optimum design. It is optimistically expected that such a decision (Block No. 37) can be reached by April, 1962, and procurement begun at that time for extensive connector replacement. The Integration Chart shows mass installation of new connectors in conjunction with crossheader modifications and fitting enlargement (Blocks No. 54, No. 59, No. 65, and No. 68). If desired, of course, connector installation could be phased in on an individual basis.

5. Rear-Face Parker Fitting Repair and Enlargement

This work can be further subdivided into the following groups.

a. Inspection of Existing Fittings - Starting Blocks No. 2 and No. 9

Visual inspection by Plant Engineering personnel of selected fittings in place is under way for evidence of visible damage, and will continue until instrumentation is received for either ultrasonic or Magnaflux testing. Upon receipt of the necessary instruments, a sampling of fittings from all five reactors will be carefully tested for cracking and erosion. Although such results are not expected, a high percentage of the tested fittings showing such damage would be cause for a major effort on repair or replacement rather than modification.

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b. Development of Fitting Repair Techniques - Starting Blocks No. 7 and No. 24

A temporary method (Dresser Saddles) has been developed to provide emergency repairs for any fitting which may fail in the next few months until a satisfactory permanent repair is developed. It may also be necessary to use this temporary repair initially for sample fitting removal if trepanning of the crossheader is done instead of sectioning.

c. Testing of Removed Fitting Samples - Starting Block No. 15

Production Test IP-362-AE⁽⁹⁾ calls for removal of sample fittings from B, D, F and H Reactors in addition to removal of a complete crossheader from DR. The removed fittings will be subjected to metallographic examination for evidence of damage or changes in micro-structure. In addition, a portion of the fittings will be enlarged and tested for mechanical strength and susceptibility to swaging of the neck of the fitting. Results of these inspections and tests will be correlated with the on-reactor inspection discussed in (a) above.

d. Complete Modification of Existing Crossheader - Starting Block No. 3

It is proposed to perform a production test involving complete modification of an existing crossheader, including expansion joints, new connectors, and enlarged fittings. This production test is not the same as Production Test IP-352-AE which calls for removal of a crossheader, the purpose of the former being to test hydraulic and vibration behavior of a header with modified fittings, the latter to obtain samples for metallographic analysis.

e. Decision Blocks No. 33 and No. 34

With results of the above inspections and tests, plus information from the flow studies and fuel studies referred to in part 2 above, it is expected that a decision as to the justification and extent of rear-face modifications may be made by February 1, 1962. Design of any necessary hardware should also be nearly complete by that time, except for changes that may be indicated by the results of the tests. At that time, Plant Engineering will submit to the Manufacturing Section a study report with recommendations.

(9) HW-66339 (Uncl) "Production Test Authorization PT-IP-352-A - Reactor Rear-Face Piping Examination, 105-B, D, F, DR, and H", O.E. Adams and J. M. Fox, Jr., dated April 11, 1961.

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VI. ACKNOWLEDGMENT

The following individuals were of special assistance to the authors in preparing this report: C. P. Cabell, Facilities Engineering Operation, on the Program Integration Chart; J. H. Hoage, Plant Engineering Operating, on the metallurgical history of the rear-face piping; L.B. Brinkman, Plant Engineering Operation, on the water plant planning; and S.M. Graves and J. L. Benson, Reactor Engineering Operation, on reactor loading possibilities.

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TABLE A - I

HARDWARE COMBINATIONS USED FOR CALCULATIONS

<u>CASE</u>	<u>CONNECTOR O.D.</u>	<u>NOZZLE FITTING I.D.</u>	<u>HEADER FITTING I.D.</u>	<u>CHARGE DESIGNATION</u>	<u>NOMINAL CENTRAL ZONE TUBE FLOW GPM</u>	<u>TOTAL REACTOR FLOW GPM</u>
A	5/8"	0.469	0.469	O-II-N-34	47.5	86,000
B	5/8"	0.469	0.469	O-III-N-32	49.0	88,000
C	5/8"	0.469	0.469	O-IV-NB-32 (5 mil reduction)	50.2	90,900*
X	3/4"	0.650	0.469	O-III-NB-32	50.6	90,200**
Y	5/8"	0.610	0.610	O-III-NB-32	50.6	90,200**
Z	3/4"	0.650	0.610	O-III-NB-32	51.4	91,400**

* Based on 1860 modified tube charges

** Based on 1400 modified tubes

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Figure 1 - Process Water Supply and Demand Curves

(See Table A - I for Hardware Combinations)

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Figure 2 - Typical Predicted Pressure Profiles - 105-F

(See Table A - I for hardware code)

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QTY.	PT. NO.	DESCRIPTION
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GENERAL NOTES

- ALL PARTS (UNLESS NOTED) SHALL CONFORM TO THE FOLLOWING:
 - TOLERANCES, EXCEPT ON HOLE DIAMETERS, ARE:
FRACT. ± DEC. ± ANGULAR ±
 - HANFORD STD. SPEC. HWS-7507-S (LIMITS OF ACCEPTABLE SHOP WORKMANSHIP).
 - ALL CUT SURFACES $\sqrt{\text{ }}$ (ASA B46.1-1955).
 - DIMENSIONS LABELED "STOCK" SHALL CONFORM TO APPLICABLE ASTM STD. TOLERANCE
- ALL MATERIAL TO BE AS SPECIFIED OR EQUAL.
- SYMBOLS AND DIMENSIONING METHODS ARE IN ACCORDANCE WITH ASA STD.
- FOR TUBE SPECIFICATIONS SEE SPEC. OR PURCHASE ORDER.

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UNIT	DIM A
DR	8 ¹ / ₈
B, D & F	10 ¹ / ₁₆
DR	7 ¹¹ / ₁₆
B, D & F	9 ⁵ / ₈

☒ CHECK PRINT		☐ COMMENT PRINT		APPROVED FOR CONST.		U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC	
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APPROVED FOR PURCHASE				APPROVED FOR DESIGN			
BY				BY			
DATE				DATE			
SCALE NONE				M REAR FACE FLEXIBLE CONNECTOR			
DRAWN <i>28 Hallett</i> 3/24/61				BY <i>J. H. Boyd</i> 3-27-61			
CHECKED <i>H. H. Hallett</i> 3/24/61				DATE <i>3-27-61</i>			
ISSUED <i>H. H. Hallett</i> 3/24/61							
DES. ENG. <i>H. H. Hallett</i> 3/24/61							
PROJECT <i>10194 F</i>							
INST. NO. <i>10194 F</i>							
CLASSIFICATION <i>R. W. Williams</i>				CLASSIFICATION			
DATE <i>3-24-61</i>				NONE			
DWG. NO. <i>SK-1-4790</i>		DRAWING TITLE <i>2200</i>		BLDG. NO. <i>105B, D, DR & F</i>		INDEX NO. <i>2200</i>	
REFERENCE DRAWINGS				DWG. NO. <i>SK-1-4791</i>		SMT. NO. <i>1</i> SHEETS <i>1</i>	
USED ON <i>SK-1-4790</i>		<i>2200</i>

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SK-1-4735

ANT INFORMATION
DRAWING

CHECK PRINT ISSUE NO. 14 DATE 4/26/61 SCALE NONE DRAWN 3 E Hallett DATE 2/28/61 CHECKED Jettings DATE 4/26/61 ISSUED J.D. Smith DATE 4-25-61 DES. ENG. 4/1 PROJECT INST. NO. 10187 F CLASSIFIED BY S.E. Jettings DATE 2/28/61		COMMENT PRINT ISSUE NO. DATE APPROVED FOR PURCHASE BY FOR DATE APPROVED FOR DESIGN BY FOR DATE CLASSIFICATION NONE		U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC I.P.D. DRAFTING TEMPORARY REPAIR HEADER FITTING BLDG. NO. 105B,D,F&H INDEX NO. 2200 DWG. NO. SK-1-4735 SHT. NO. 1 SHEETS 1	
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REF. NO.	DWG. NO.	DRAWING TITLE
		REFERENCE DRAWINGS
		NEXT USED ON

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REFUSED

H-1-12767

FOR
MODIFICATION
SEE DRAWING
H-1-12821

- GENERAL NOTES
1. ALL PARTS (UNLESS NOTED) SHALL CONFORM TO THE FOLLOWING:
 - A. TOLERANCES, EXCEPT ON HOLE DIAMETERS, ARE:
FRACT. & $\frac{1}{32}$ DEC. & ~ ANGULAR < 2°
 - B. HANFORD STD. SPEC. NWS-7907-5 LIMITS OF ACCEPTABLE SHOP WORKMANSHIP.
250° (ASA B46.1-1958)
 - C. ALL CUT SURFACES (ASA B46.1-1958)
 - D. DIMENSIONS LABELED "STOCK" SHALL CONFORM TO APPLIC. ASME ASTM STD. TOLERANCE
 2. ALL MATERIAL TO BE AS SPECIFIED OR EQUAL
 3. SYMBOLS AND DIMENSIONING METHODS ARE IN ACCORDANCE WITH ASA STD.

4	P-1319	PROC. WATER PIPE-SUPPORT ARRGT
3	P-1316	PROC. WATER PIPE-MISC SUP. DETS
2	P-1295	PROC. WATER PIPE ARRGT-OUT-ELEVS
1	P-1259	PROC. WATER PIPE ARRGT-OUT-PLANS
REF. NO.	OWG. NO.	DRAWING TITLE
REFERENCE DRAWINGS		
NEXT USED ON		

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DATE <u>1/13/50</u>		INSTR. NO. <u>1</u>		DATE <u>1/13/50</u>					
APPROVED FOR PURCHASE									
BY		JOB DATE		BY					
SCALE <u>NOTED</u>									
DRAWING <u>W.E. WHYYOCK</u>		DATE <u>1/13/50</u>		APPROVED FOR DESIGN					
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DESIGNED <u>W.E. 1/8</u>		DATE <u>1/13/50</u>							
DRAWN <u>VERMILION</u>		DATE <u>1/13/50</u>							
PROJECT <u>10593</u>									
CLASSIFICATION									
DATE <u>1/13/50</u>				NONE					
BLANK NO. <u>105-H</u>						WORK NO. <u>8401</u>			
ORDER NO. <u>H-1-12767</u>						INST. NO. <u>-</u>		REVISED <u>-</u>

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