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PIPING CHANGES FOR INCREASED PRODUCTION
AT B, D, DR, F, J, AND H REACTORS

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AT B, D, DR, F, C, AND H REACTORS

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January 22, 1960

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TABLE OF CONTENTS

	<u>PAGE NO.</u>
I. PURPOSE OF STUDY	3
II. BACKGROUND INFORMATION	4
III. RECOMMENDATIONS	5
A. For Increased Flows at Present Temperatures	7
B. For Increased Flows at 105° C Bulk Outlet Temperatures	7
IV. COST ESTIMATES	9
V. TECHNICAL DISCUSSION	13
A. Fittings	13
B. Stresses in Crossheaders and Risers	14
C. Need for Replacement and Additional Crossheaders	15
D. Water Temperature during Transient Surges	16
E. Crossheader Pressures Required	17
F. Pressurized vs. Singly Orificed Crossheaders	19
G. Capacities of Downcomers and Effluent Lines	20
H. Depressurizing Stations	27
I. External vs. Immersion Water Temperature Detectors	27
VI. BIBLIOGRAPHY	29
VII. APPENDIX - SUPPORTING DATA AND DRAWINGS	A-1

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PIPING CHANGES FOR INCREASED PRODUCTION
AT B, D, DR, F, C, AND H REACTORS

I PURPOSE OF STUDY

This study proposes improvements in the process water piping adjacent to the front and rear faces of these reactors. The value of these proposed changes will depend in part on the outcome of parallel studies being prepared by the Irradiation Processing Department on:

- a. Changes in reactor process tubes and fuel elements.
- b. Coolant pumping and power supply equipment.
- c. Instrumentation for both normal and transient conditions.
- d. Retention basins and outfall lines.

It is understood that the results of the several studies will be combined in an over-all report which will include summary recommendations.

Specifically, the present report covers the external piping of the reactors from the incoming valve pit to the inlets of the outgoing retention basins, and discusses:

1. Changes in pigtails, fittings and crossheaders to reduce water velocities and thereby conserve water pressure at present flow rates (approximately 80,000 gpm per reactor) and present bulk outlet temperatures.
2. If the pigtails and fittings are to be changed, some improvement of flow conditions and some reduction of maintenance are attainable by using external devices for temperature monitoring. Although this item is not a main objective of this report, the possibility of over-all economies by including this change is worth considering. This subject is treated further under Section V, Technical Discussion, but costs have not been estimated.
3. Additional changes to accommodate the following higher rates of water flow, at substantially the present bulk outlet temperatures (93-95° C).

<u>B, D, DR, F, H</u>	<u>C Reactor</u>
95,000	
105,000	105,000
115,000	115,000
150,000	150,000

Due to later instructions, the engineering of downcomers and effluent lines for 150,000 gpm has not been completed.

4. Depressurizing means for bulk effluent temperatures below 100° C.
5. To illustrate the need for dissipating energy if the effluent water temperature is above 100° C, preliminary design has been prepared for a depressurizing station for 105° C effluent, to be located external to the reactor building.

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HW-63487
Page 4

6. Changes of valve pit manifolds and front risers, for extremes of increased flow.

II. BACKGROUND INFORMATION & PRESENT ASSUMPTIONS

A. Present vs. Original Design Flow Rates and Temperatures

The old reactors, B, D, & F were designed for water flow of 30,000 gpm and a maximum outlet temperature of 65° C, the bulk outlet temperature being substantially lower. These figures represent 250 MW of heat generation. The old pumps delivered water at 350 psi. Today the coolant flow per reactor is typically 80,000 gpm and the bulk outlet temperature is near 95° C, representing approximately 1600 MW of heat generation. The present pumps operate above 600 psi discharge pressure. Thus these reactors are now operating at 6-1/2 times the original design rating, and are still using the original crossheader piping and fittings. These figures indicate that stresses due to higher hydraulic pressure and to temperature expansion are already considerably above those originally contemplated in the design.

B. Temperature Expansion and Piping Stresses vs. Those Originally Contemplated

As noted in the preceding paragraph, the original design of piping was made for lower flow and temperatures. Due to the increased operating temperatures already in effect, serious overstresses now exist at various points in the crossheader-to-riser connections of B, D, DR, F, C, and H reactors; in time, these will require more extensive maintenance to continue present levels of production.

C. High Water Velocities, Pressure Drops and Evidences of Cavitation at Present Flows

The B, D, DR, F, and H reactors have small fittings with minimum flow diameter of 0.469". In an average power tube the present velocity through the rear-face fittings is approximately 80 ft./sec., and the average pressure loss in the rear-face fittings alone is over 80 psi. So large a loss contributes to high-frequency vibrations and to erosion, resulting in present and future maintenance problems. Wear due to cavitation is evident in the tapered inner surface of the cross-header tube fitting. Failures in that connector will probably occur soon in increasingly large numbers; the welded joint between the cross-header fitting and the crossheader may be expected eventually to start its failure pattern in a similar manner. The timing of major breakdowns at these points is difficult to determine because no quantitative data are available.

D. Effects of Power Surges When the Normal Bulk Outlet Condition is Near Boiling

Under the original design conditions (maximum effluent temperature 65° C) for B, D, and F, a substantial power excursion could be tolerated without approaching boiling temperature.

At the present normal bulk effluent temperature (about 95° C) a power surge could take the effluent temperature above 100° C. For the purpose of this study, no special provision for such transients is considered necessary; the reasoning is outlined in Sec. V, Technical Discussion.

E. Tabulation of Assumptions for Conditions of Increased Output

1. Stress calculations are based on pipes being assembled at room temperature (70° F) with no cold spring.
2. To determine stress on inlet crossheaders, operating conditions 200°F, and 100 psig were assumed, (i.e., recirculating operation).
3. Pressure losses across the front face strainers were calculated from flow testing curves made upon the strainer before installation. These pressure losses are very small, and do not reduce significantly the pressures on the elements downstream.
4. Flow distribution through all six reactors is assumed similar to the data supplied for the DR reactor (Fig. 1, Page 6) and will have similar proportions for higher flows.
5. The specified rates of water flow are assumed to occur at 20° C inlet temperature.
6. In general, the rear crossheaders are not assumed to be pressurized beyond the heads at which they now operate. However, one case is presented, typical of B, D, and F reactors, in which the rear crossheaders are assumed to operate at the following pressures:

<u>Flow, GPM</u>	<u>Pressure, PSIG</u>
95,000	40
105,000	50
115,000	60
130,000 and over	75

Such pressurization would assure reverse flow of coolant through a process tube, assuming a failure at the front face. It would also require a new riser and downcomer and a pressure-reducing station to be located just outside the reactor building.

III. RECOMMENDATIONS

To illustrate the piping arrangements proposed in the following, new drawings are referenced at the end of this section.

A. Changes to Improve Operation at Present Power Levels

These changes are detailed in Tables I, II, III, and IV in Sec. VI of this report.

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As a quick summary, the changes for B, D, DR, F and H reactors include replacing the 5/8" fittings with 1" sizes at the front and rear faces, replacing the outlet crossheaders, risers and riser supports, as well as modifying the B-D-F downcomers. For C reactor, only the riser supports actually need to be changed, although substantial power is being lost in the 5/8" inlet fittings.

B. Total Changes Needed for Higher Flows with Bulk Outlet Temperatures Limited to 95° C

These changes also are listed in Tables I, II, III, and IV, the latter summarizing changes and additions needed in downcomers and effluent lines of all reactors. For 115,000 gpm flow, the DR and H reactors require new inlet and outlet fittings, the riser changes specified above, and additional crossheaders with valves and fittings; these reactors already include dual effluent lines which should be vented near the downcomers. The C reactor requires only new and larger inlet fittings, a new riser support to allow limited movement, and minor changes in the effluent system.

For all six reactors the additional case of 150,000 gpm flow has been studied, as regards front and rear-face piping only. Since the additional changes required at this flow are far-reaching, it is best to refer directly to Tables I, II, III.

C. Pressurizing for Reverse Flow at 95° C

This refers to Sec. II-E, and to the specific case of an assumed break in a process tube or a front-face pigtail, requiring reverse flow of coolant. Since neither the rear-face risers nor the downcomers are suitable for substantial hydrostatic pressures, this case calls for:

- New risers and crossover pipes.
- An extension of the crossover line beyond the 105 Building Wall.
- A new pressurized, shielded (outdoor) downcomer.
- A pressure-reducing station, out-of-doors.

For the assumed bulk temperature of 95° C, no supplementary flow of coolant is needed for quenching.

It is understood that the need for reverse flow is still under discussion, and therefore these recommendations are tentative.

D. Definition of Changes and Components Needed in a Pressurized Effluent System for 105° C Bulk Outlet Temperature

This case has been included for comparison with the 95° C case, for the same range of flow rates. The required changes are detailed in Section VI of this report, Tables V, VI, VII.

As a quick summary, the changes in front and rear face fittings, crossheaders and risers are the same as those listed in Tables I, II, III for increased flows at 95° bulk outlet temperature.

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For 105° C bulk temperature, however, it is definitely necessary to pressurize the effluent system, involving the following additions or changes:

- New risers and crossover pipes, with heavier walls.
- New pressurized shielded (outdoor) downcomers.
- A supply of quench water (to reduce bulk temperature to 95° C).
- An energy dissipator to permit reducing the water pressure and to provide for the transient disposal of steam formed during a reactor shutdown following a failure of quench water.

The means for providing and controlling the supply of quench water, if used, will be described by others in another section of the over-all report.

E. Changes of Valve Pit Manifolds

The valve pit manifold piping is adequate for flows through 115,000 gpm in all the areas included in the study. If the flow were to be increased to 150,000 gpm, then the valve pit manifolds, tunnel piping, risers, etc., would have to be enlarged as shown on SK-1-3812, Sheet 1. The corresponding costs have not been estimated.

F. Summary of Increases Attainable in Power Output

The following tabulation defines percentages of increase in thermal output attainable by the several changes summarized above. These percentages do not take into account any possible changes in the uranium-plutonium conversion ratio.

<u>Item</u>	<u>Percent Increase Above Present Power Level</u>	
a. Improved operation at present power levels	None, except the expectation of a higher percentage of operating time.	
b. Higher flows at 95° C bulk outlet temperature	<u>B, D, DR, F, H</u>	<u>C Reactor</u>
95,000 gpm	19%	0%
105,000	30	10
115,000	44	21
150,000	87	58
c. Higher flows at 105° C bulk outlet temperature (Pressurized Effluent System)		
95,000	34%	13%
105,000	47	25
115,000	63	37
150,000	112	79

G. Reference Drawings

Page

A-9	SK-1-3812, Sheet 1	- Reactor Process Piping - Typical Flow Sheet - Front and Rear Face
A-10	SK-1-3826)	Typical Front Face Piping
A-11	3827)	(flows up to 115,000 gpm)
		Typical Rear Face Piping - Gravity Flow
		(flows up to 115,000 gpm)
A-12	SK-1-3821)	
A-13	3822)	B, D, F Reactors
A-14	3823	DR
A-15	3824	H and C
A-16	SK-1-3812, Sheet 2	- Reactor Process Piping - Typical Flow Sheet - Pressurized Rear Face & Effluent System
A-17	SK-1-3828	Typical Front Face Piping
A-18	3829	and Valve Pit
		(flows up to 150,000 gpm)
		Typical Rear Face Piping - Pressurized
		(flows up to 115,000 gpm)
A-19	SK-1-3813)	
A-20	3814)	B, D, F Reactors
A-21	3815)	
A-22	3816)	DR
A-23	3817)	
A-24	3818)	H and C
A-21	SK-1-3815)	Typical Rear Face Piping - Pressurized
A-22	3816)	(flows up to 150,000 gpm)
These drawings are representative, except		
a) Change to 5" crossheaders		
b) Use the dual downcomers in parallel		
A-25	SK-1-3819	Depressurizing Station for 95° C water
A-26	3841	Depressurizing Station for 105° C water
<u>DOWNCOMER AND EFFLUENT SYSTEMS</u>		
A-27	SK-1-3851	F-Reactor
A-28	SK-1-3842, Sheet 1	} B-C Reactors
A-29	SK-1-3842 " 2	
A-30	SK-1-3847	
A-31	SK-1-3856	
		D-DR Reactors
		H Reactor

IV. ESTIMATES OF DIRECT CONSTRUCTION COSTS

These estimates do not include any allowance for loss of production time.
The following charges are also excluded:

1. Construction Engineering
2. Contingency and Escalation
3. General Overhead
4. Management Services

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HW-63487
Page 10

The estimates are grouped to correspond with the recommendations of Sec. III, above. All costs are in thousands of dollars except the totals, which are stated in dollars.

- A. Changes to Improve Operation at Existing Flow,
with Bulk Outlet Temperature 95° C
- B. Total Changes Needed for Higher Flows,
with Bulk Outlet Temperature 95° C
- C. Total Changes Required for Existing Flows,
with Bulk Outlet Temperature 105° C
- D. Total Changes for Increased Flow,
with Bulk Outlet Temperature 105° C

A. Changes to Improve Operation at Existing Flow,
with Bulk Outlet Temperature 95° C

	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders, Valves, Strainers, Fittings	---	---	---
Outlet Crossheaders, Valves, Fittings	555	370	---
Outlet Risers	465	310	25
Outlet Crossunder Piping & Valves	75	50	---
Outlet Crossover Piping and Valves	225	290	---
Downcomer Modifications	---	---	---
Effluent Line & Junction Box Modifications	---	---	---

TOTAL FOR SIX REACTORS

\$2,365,000

B. Total Changes Needed for Higher Flows,
with Bulk Effluent Temperature 95° C
95,000 GPM Flow

	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	750	610	---
Outlet Crossheaders	555	370	---
Outlet Risers	465	310	25
Outlet Crossunder Piping	75	50	---
Outlet Crossover Piping	225	290	---
Downcomer	---	---	---
Effluent Line	---	---	---

TOTAL FOR SIX REACTORS

\$3,725,000

105,000 GPM Flow

	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	750	610	170
Outlet Crossheaders	555	370	---
Outlet Risers	465	310	---
Riser Support Modification	---	---	25
Outlet Crossunder Lines	75	50	---
Outlet Crossover Piping	225	290	---
Downcomer Modification	90	---	---
Effluent Line	150	---	---

TOTAL FOR SIX REACTORS

\$4,135,000

115,000 GPM Flow
(Non-Pressurized Effluent System)

	<u>B&D</u>	<u>F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	500	250	610	170
Outlet Crossheaders	370	185	370	---
Outlet Risers	370	155	310	---
Riser Support Modifications	---	---	---	25
Outlet Crossunder Piping	25	50	50	---
Outlet Crossover Piping	150	75	290	---
Downcomer	90	150	---	---
Effluent Line	150	90	---	---

TOTAL FOR SIX REACTORS \$4,375,000

115,000 GPM Flow
(Rear Face Pressurized for Emergency Reverse Flow)

	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	750	610	170
Outlet Crossheaders	555	370	---
Outlet Risers	465	310	---
Riser Support Modification	---	---	25
Outlet Crossunder Piping	75	50	---
Outlet Crossover Piping	405	330	---
Pressurized Downcomer	495	330	165
Depressurization Station	855	570	285
Effluent Line Modification	255	---	35

TOTAL FOR SIX REACTORS \$7,105,000

C. Total Changes Required for Existing Flow
at Bulk Outlet Temperature 105° C

<u>Existing Flow</u>	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	---	---	---
Outlet Crossheaders	555	370	---
Outlet Risers	465	310	---
Riser Support Modifications	---	---	25
Crossunder Lines	75	50	---
Crossover Lines	405	330	---
Pressurized Downcomer	495	330	165
Effluent Line Modification	710	410	600
Energy Dissipator	1585	1055	530

TOTAL FOR SIX REACTORS \$8,465,000

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D. Total Changes for Increased Flow
at Bulk Outlet Temperature 105° C
95,000 GPM Flow

	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	750	610	---
Outlet Crossheaders	555	370	---
Outlet Risers	465	310	---
Riser Support Modifications	---	---	25
Crossunder Lines	75	50	---
Crossover Lines	405	330	---
Pressurized Downcomer	495	330	165
Effluent Line Modification	710	410	600
Energy Dissipator	1585	1055	530

TOTAL FOR SIX REACTORS \$9,825,000

105,000 GPM Flow

	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	750	610	170
Outlet Crossheaders	555	370	---
Outlet Risers	465	310	---
Riser Support Modifications	---	---	25
Crossunder Lines	75	50	---
Crossover Lines	405	330	---
Pressurized Downcomer	495	330	165
Effluent Line Modification	710	410	600
Energy Dissipator	1780	1185	595

TOTAL FOR SIX REACTORS \$10,385,000

115,000 GPM Flow

	<u>B,D,F</u>	<u>DR&H</u>	<u>C</u>
Inlet Crossheaders	750	610	170
Outlet Crossheaders	555	370	---
Outlet Risers	465	310	---
Riser Support Modifications	---	---	25
Crossunder Lines	75	50	---
Crossover Lines	504	330	---
Pressurized Downcomer	495	330	---
Effluent Line Modifications	710	410	600
Energy Dissipator	1980	1320	660

TOTAL FOR SIX REACTORS \$10,719,000

V. TECHNICAL DISCUSSIONA. Inlet and Outlet Fittings

The B, D, DR, F and H reactors have 5/8" fittings on front and rear faces. C reactor has 5/8" front and 1" rear face fittings. For the five older reactors a change to 1" fittings, front and rear, is strongly recommended, even for operation at present flow conditions. At 80,000 gpm per reactor the average flow per tube is 40 gpm but about 1500 tubes typically carry 45 gpm each. At this flow about 87 psi is lost in the front fittings and 96 psi in the rear fittings. This total loss of say 183 psi is 30% of the pressure generated by the process pumps. For an entire reactor the direct loss is over 7,000 HP. This power is dissipated in turbulence at the front and rear faces and is responsible for the high-frequency vibrations which have been measured in piping adjacent to the reactor faces. The magnitude of this power loss is easily understandable when it is considered that these fittings are being used at nearly three times the flow rate originally contemplated

With the 1" fittings proposed for the front and rear faces, this loss will be reduced by more than 90%, i.e. to less than 700 HP per reactor. The power saving, considering pump and motor efficiencies becomes approximately $6300 \times .746 = 5700$ KW per reactor, which might be used to reduce ⁸² demand and power cost. At \$20/KW-year the annual saving is \$114,000 per reactor, or about \$570,000 annually for the five reactors. If the small front-face fittings of C reactor also were changed, approximately \$57,000 additional savings can be foreseen.

Alternatively, the pressure thus saved might be used to increase water flow and reactor output, subject to any required changes in pump characteristics.

At the rear face there is additional urgency for changing these fittings, as follows: A high-power tube may operate as much as 20°C higher than the 95°C bulk outlet temperature. As an example, a tube with 48 gpm flow and 115°C actual outlet temperature needs about 180 psi rear nozzle pressure and about 73 psi rear crossheader pressure to prevent local boiling. The evidences of cavitation already observed in typical fittings foreshadow the increased maintenance to be expected where the necessary rear crossheader pressure is not maintained. For contrast, if 1" fittings are installed, about 23 psi at the rear nozzle and 13 psi at the crossheader are adequate to prevent local boiling and cavitation; these pressures are not far from the range afforded by the normal hydrostatic head in most portions of a reactor.

The C reactor already has large fittings at the rear face, and only the front fittings presently represent a high pressure and power loss. Since there is no further saving to be made at the rear face fittings, the front-face fittings are the only parts of the reactor face piping which offer possibilities for reducing the pressure loss and thereby increasing the water flow.

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B. Stresses in Crossheaders and Risers at Temperatures Above Original Design Conditions

Significant stresses in these members can arise from three sources:

1. Crossheader vibrations of large amplitude have been reported where existing supports are not adequate to restrain movement.
2. Cavitation where the fittings join the crossheader may have eaten into the header material at some points.
3. Thermal expansion of crossheaders imposes high (an non-uniform) stresses at the joint between crossheader and riser.

As regards item 1, stresses cannot be calculated in the absence of specific measurements. It is reasonable, however, to suspect that sizable stresses may have existed. In addition, any large amplitude at a crossheader means that tube fittings and pigtails had to move correspondingly, causing undetermined local stresses.

Item 2 is speculative. Erosion in the fittings has been observed and reported. As this progresses, the thin section of a fitting can be worn away, permitting erosion to continue on the crossheader metal. Long-continued observation of numerous joints would be needed to appraise this risk.

For item 3, stress values can be approximated. Assuming a crossheader fixed at midpoint and taking its length as normal at 20° C, the linear expansion has been calculated for the present bulk outlet temperature of approximately 95° C.

The riser mountings should be changed to permit the entire riser to move horizontally, to accommodate the linear expansion of the crossheaders. Since this flexibility is presently lacking:

- a) The push of all the crossheaders, when heated, tends to move the riser, and thus distorts the thin wall of the riser.
- b) The crossheader extension is deflected away from its normal position which is radial to the riser (Fig. 2)

FIG. 2

NOTE: Arrows show directions of movement as water temperature rises.

Crossheader connections to riser,
B, D, DR, F, H, & C Reactors

Since the risers are of only 3/16" steel and are 36" in diameter, the walls lack stiffness and the metal will be deformed by any sizable movement of the crossheader extension, which is welded into the riser.

- c) Unequal elongations of crossheaders, when operated at different water temperatures cause unequal amounts of distortion at the crossheader riser joint.

Stresses in the riser material, corresponding to the cold-to-hot elongation of a crossheader, are calculated to be far higher than the strength of the material. Actually this means only that the wall of the riser, under the assumed conditions, will be deflected beyond its elastic limit as the crossheaders heat up and will tend to return as the crossheaders cool down. The total number of such stress cycles in a year, or in ten years, is not large but some risers have failed at crossheader-to-riser joints.

As mentioned in c) above, there can also be shearing stresses in a riser if one crossheader runs much hotter than the adjacent one; this can occur because enrichment makes it possible to control power levels in individual process tubes or rows of tubes. Any numerical calculations depend heavily on the conditions assumed.

Real improvement is possible by providing new riser supports which will enable the riser to move horizontally as the crossheaders heat up.

C. Specific Need for Replacement and Additional Crossheaders

Crossheaders must be added at B, D, F, DR & H so that each crossheader supplies only one row of tubes. The 4" size allows space to maintain the existing gas seals. For flows thru 115,000 gpm, it is recommended that a complete new set of 4" crossheaders be provided for both the front and rear faces of these reactors. For 150,000 gpm flow, 5" crossheaders would be needed to avoid excessive velocities, pressure losses and vibration. Larger crossheaders in turn would require gas seals of a new design.

The recommendation to provide new crossheaders is based on the following reasons:

1. Having new crossheaders ready for installation should reduce the shutdown time for changeover, compared to removing, reworking and reinstalling the present crossheaders.
2. In some portions of B, D, DR, F and H, two rows of process tubes discharge into a single crossheader. New additional crossheaders are needed to realign the flow, i.e., to provide one crossheader for each row of tubes.

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HW-63487
Page 16

3. Since some of the old crossheaders have been subjected to severe vibrations and thermal stresses, the present integrity of the metal cannot be guaranteed.
4. Boring out the old fittings (which are nitrided, and welded into the crossheaders) would be a difficult, exacting and costly job, with many chances of spoiling some of the pipes.
5. Before reconditioning could be started, time and expense would be required for decontamination, extent uncertain.

C reactor already has 1" pigtail fittings on the rear face and can continue to use its 4" outlet crossheader for flows through 115,000 gpm, but would require an increase to 5" pipe size above that flow, due to high velocity and pressure drop.

The rear risers are of 1/2" wall thickness, adequate to withstand the pressures corresponding to 115,000 gpm flow. However, new movable riser supports are needed to reduce stresses caused by temperature expansion.

D. Temperature Under Assumed Transient Surges

Many studies have been conducted to determine the effects of power surges on Hanford Reactors and their associated piping. A few of the principal findings will be repeated here for their particular bearing on the current question of pressurizing the rear crossheaders.

HW-51327 (May, 1957) states that a tube outlet temperature surge is delayed 6 to 17 seconds before reaching the low-pressure point at top of riser. Assuming a scram, six seconds is said to be time enough for the reactor power level to drop below 60% of the previously steady level, while the coolant flow is still about 80% of normal. The author states that temperature mixing in the risers and crossovers (with water which left the reactor tubes a little earlier) tends to reduce the tube outlet transient to 50%, and possibly much lower, at the top of downcomer.

Based on both of these factors, the transient temperature rise at the top of the downcomer is much less than the bulk temperature rise at the various tube outlets.

HW-52793 (March, 1958, by the same author) reviews the problem in the light of higher prospective effluent temperatures. The worst condition is indicated to result from the discharge of a poison column, or the accidental withdrawal of a control rod with delayed trip, and is estimated at plus 12°C. initial rise of water temperature. Judging from the earlier report, however, only about 50% of this temperature increase would appear, after some seconds delay, at the top of the riser or the downcomer.

Still more recently (Sept., 1959) HW-62113 proposes that such accidental transients be reduced by:

- a. Using a "deadman's" switch to limit the effects of inadvertent withdrawal of a control rod.
- b. Standardizing the present operating practice of using only half-length poison columns. The surge following an accidental discharge is defined as 5° C. maximum.

On the basis of these improvements, the use of 95° C bulk outlet is authorized by the Research and Engineering Operation of the Irradiation Processing Department.

In the present study we are considering high-flow operation at 95° C bulk outlet temperature without pressurizing the downcomers. The problems are:

- a. To avoid the possibility of choking the downcomer with steam, since this would restrict the flow of coolant.
- b. To avoid the possibility of pressurizing the present downcomers, since this could cause physical damage.

Considering the surge-limiting effect of the new proposal (HW-62113) and the "time-phase" reduction between tube outlet and top of downcomer (HW-51327) it is our belief that operation at 95° C bulk outlet temperature is compatible with the retention of non-pressurized downcomers, even at the increased flows contemplated. This, however, relies on the individual orificing now in use on the more heavily loaded crossheaders, and discounts any need to provide for reverse flow of coolant in case of a tube failure.

On the other hand, any bulk outlet higher than 95° C would almost certainly call for pressurized downcomers.

E. Crossheader Pressures

1. For Normal Flow Conditions

If the fittings of B, D, DR, F and H reactors are changed to 1", the following tabulation (adapted from HW-62729) indicates approximately the rear nozzle and crossheader pressures needed for typical high power tubes. Assume for illustration that 115° C maximum tube outlet corresponds to a bulk outlet of 95° C, and that 125° C maximum corresponds to a bulk outlet of 105° C. The flows shown are representative of high-power tubes:

DECLASSIFIED

B - D - DR - F and H Reactors
Rear Nozzle and Crossheader Pressures Required
with 1" Fittings (.0870" I.D.)

Typical Flow &
Outlet Temp. for
High-Power Tube

Reactor Coolant Flow GPM	Flow GPM	Outlet Temp. Deg. C	Rear Nozzle Pressure (PSIG)	Rear Header Pressure (PSIG)	Saturation Pressure (PSIG)
80,000	48	(115 125)	25 34	15 24	10 19
95,000	57	(115 125)	31 40	18 27	10 19
105,000	63	(115 125)	36 45	19.5 28.5	10 19
115,000	69	(115 125)	41 50	21 30	10 19

Note that the rear crossheader pressures specified in this tabulation are only slightly above those required to suppress boiling, without any allowance for velocity pressure, at the temperatures assumed for high-power tubes. This means that very little margin is reserved against the further reduction of pressure which occurs at the high velocity point in the fittings. Further, these very modest pressures include no margin to protect against boiling which might start in the high-power tubes during a power surge. In practice, somewhat higher pressures might be found desirable.

Therefore, these pressures should be regarded as about the minimum to be maintained, even with the larger fittings, in those crossheaders which receive the discharge from high-flow tubes. With the present small fittings, some degree of pressurization is being provided by orificing individual crossheaders but the extent and adequacy have not been examined. The advantages of overall pressurization are discussed further in Section V-F.

2. Provision for Abnormal Conditions, Such as Reverse Flow Through a Broken Process Tube

As mentioned in Section II, above, rear crossheader pressurization is being considered to insure a reverse flow of coolant to a ruptured process tube tentatively as follows:

Flow, GPM	Rear Crossheader Pressure
95,000	40 psig
105,000	50
115,000	60
150,000	75

DECLASSIFIED

HW-63487
Page 19

These pressures have been estimated by members of the Irradiation Processing Department as adequate to prevent melting fuel elements. Note that these crossheader pressures would be quite adequate to prevent boiling under the normal flow conditions described above.

Thus, a moderate pressurization of the rear crossheaders would serve the dual purpose of preventing local boiling and of insuring a reverse flow of coolant to a broken process tube. It would also permit some further increase in bulk outlet temperature, if found desirable from other standpoints.

F. Value of Pressurized Effluent System vs. Orificing of Individual Crossheaders

In Section V-E it was shown that reasonable pressures above atmospheric should be maintained in some of the rear crossheaders, even at 95° C bulk outlet temperature, to provide for a) the higher discharge temperature of the high-power tubes. b) The velocity pressure through the proposed 1" fittings, even though this pressure is not large.

Consider further that back pressures of 40-60 psig may be needed to insure reverse flow of coolant to a broken process tube, and that some of the present risers are overstressed, so that replacement is desirable; also that without pressurization, 95° C appears to be a limiting bulk outlet temperature, from the standpoint of safety during power surges. At present, back pressures are being provided for certain high-power tubes by orificing only certain individual crossheaders.

If provision for reverse flow is to be made, pressurized downcomers should be added to the list of changes proposed for B, D, DR, F and H reactors. The downcomers and pressure-reducing stations represent the principal new items needed, since new risers are recommended quite apart from the decision on pressurization. At C reactor, there is less justification for changing the downcomer, except as this would pave the way for operation at bulk outlet temperatures above 95° C.

A moderate pressurization of the rear crossheaders, risers and downcomers of the B, D, DR, F and H reactors offers the following advantages:

1. Power loads of single tubes or groups throughout the reactor can be adjusted over wide ranges without the danger of boiling at the rear face fittings. Thus flexibility of operation can be improved.
2. The need for records of individual orifice sizes and locations at the rear crossheaders can be eliminated, because rear-face pressures can be controlled at a single depressurizing point. Chances for errors in such records, and in operation, can be reduced correspondingly.
3. Where individual crossheaders are orificed to provide any sizable back pressure, the reduction of pressure should then be made in steps, by using 2 or 3 orifices in series (see HW-50104). This additional complication can be avoided by pressurizing the rear face piping and the downcomers as a unit.

4. The control of flow in single tubes can then be controlled by orificing at the front face only. This is simpler than a system which requires that front-face orificing be made compatible with row-by-row variations in the orificing of rear crossheaders.
5. If there is any advantage in "leaving the door open" for operation beyond 95° C bulk outlet, the changes to make this possible can be made while the reactors are down for the other major changes recommended in this report.

G. Downcomers and Effluent Line Systems

General

To determine the existing capacity of downcomers and effluent lines and the modifications needed to accommodate modifications to increase their larger flows, the following basic assumptions are made:

1. The 105-C, DR and H buildings each have two downcomers and parallel effluent lines. It is assumed that these downcomers and effluent lines can be used simultaneously, each taking one half the flow and thereby essentially doubling the capacity of the system.
2. Two dual areas are considered by this study; the 100-B, C area and the 100-D, DR area. In these areas it is assumed that each effluent system must be capable of handling the operating flow of its reactor plus the shutdown flow of the other reactor. The shutdown flow for the purpose of this study is taken at 10,000 gpm.
3. The 100-B, D, F and H retention basins are concrete structures consisting of two independent basins which originally operated separately. It is assumed these basins will operate simultaneously in parallel.
4. The 100-B effluent line discharges into the 107-B basin through two 60" electrically operated gate valves. Inadvertent closure of the two gate valves simultaneously would force the effluent flow through a small by-pass. It is assumed that the system must be able to operate with these valves closed without backing water to the top of the downcomer; because of pressurization under this condition it would be acceptable to have water leaking from the junction boxes.
5. A new 66" diameter line between the 100-B effluent system and the 107-CW basin, and modifications to the 107-C diversion box are presently being proposed by Study No. HW-61206 - Effluent System Modifications 100-B, C. It is assumed this work will have been done when the work contemplated by the subject study is undertaken.

Subject to these assumptions the downcomer and effluent line systems in the 100-B, C, D, DR, F and H Areas are analyzed for flows of 95,000, 105,000 and 115,000 gpm with the water temperature at 95° C. The system capacities are determined by two factors:

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1. The structural adequacy of the downcomer and its enclosing concrete walls in the 105 Building.
2. Downcomer hydraulic characteristics together with those of the effluent line system.

The structural problem has been investigated and is reported in a letter dated April 15, 1957, written by R. F. Jimenez to H. W. Heacock. This letter reports the allowable pressures which the existing downcomers can accommodate and is the basis of the structural recommendations contained in this report. In the case of the 105-F building it is possible to increase the allowable pressure in the downcomer over that recommended by the above letter by reinforcing the structure. This is discussed in more detail later.

The hydraulic capacity of a downcomer and effluent line system is difficult to determine by analysis alone. Because of this a contract has been negotiated with the R. L. Albright Hydraulic Laboratory at Washington State University to test models of existing downcomer and effluent line systems and determine their capacities. At the time of this writing the work under this contract has not been completed. However, the work that has been done is the best information available and offers a method for making a reasonable determination of downcomer and effluent line capacities. This work is reported in the following studies:

- GEH-24162 - Hydraulic Model Studies of the 100-F Downcomer & Effluent System Contract No. DDR-41, Work Phase I
- GEH-24387 - Hydraulic Model Studies of the 100-F Downcomer and Effluent System, Phase II
- GEH-24477 - Supplemental Report on 100-F Downcomer and Effluent System
- GEH-24522 - Hydraulic Model Studies of 100-DR and 100-F Downcomers Supplemental Contract No. 3 - DDR-41

These studies pertain principally to the 100-F system and are the basis of the present analysis of that system. However, report GEH-24522 develops general analytical methods for determining downcomer and effluent line capacities and pressures. Where actual test information is not available these methods are used.

105-F Downcomer and Effluent Line System - Structural Study

SK-1-3851 shows the proposed modifications to downcomer and effluent line for non-pressurized flow.

The 105-F Building contains one downcomer. This is encased by two 2-foot thick walls, a 3-foot thick wall and a 5-foot thick wall. Because of the method of construction it is assumed that the downcomer forces are transmitted directly into these walls. The 2-foot thick wall between the downcomer and the riser space has a span of 11-feet and is the weakest of the elements surrounding the downcomer. The letter mentioned above recommends that a head of 20-ft. in the downcomer not be exceeded. This is based on the allowable capacity of the above mentioned wall.

If the lower section of this wall is reinforced, and this is possible, then the controlling structural element will be the other 2-feet thick wall which has a span of 8-feet. This wall is capable of withstanding a pressure equivalent to 30-feet of head. Therefore, it is recommended that the lower section of the wall between the downcomer and the riser be reinforced for all flows above the existing flow and that a head of 30-ft. be assumed as the governing value for the existing downcomer.

Document GEH-24477 recommends changes to the 105-F downcomer and effluent line system and reports flow conditions together with downcomer pressures after these changes have been made for flows up to 100,000 gpm.

The modifications recommended are:

1. Installation of an elbow where water enters the downcomer.
2. Perforation of all downcomer baffles.
3. Removal of the present downcomer baffle vent pipes.

Reading directly or extrapolating document curve values gives downcomer pressures for the 95,000 gpm and the 105,000 gpm flow condition.

Flow GPM	Maximum Downcomer Pressure in Feet of Head			
	Bottom	Front Face	Left Side	Right Side
95,000	23	28	26.75	28.75
105,000	25	32	30.25	32.25

Several of the above pressures for the 105,000 gpm flow condition are greater than the 30-ft. of head that the building concrete, as reinforced, is able to support. The values are so close, however, that it is concluded that structurally the existing 105-F installation, if reinforced, is adequate to handle flows up to 105,000 gpm if the downcomer is modified as outlined above.

For the 115,000 gpm flow condition stresses would be greater than the building could safely withstand and it is recommended that an additional downcomer be added to cut the flow per downcomer in half and thus reduce the stresses well below the allowable.

105-F Hydraulic Study

Figure 5 of document GEH-24477 shows that the existing downcomer and effluent line system, modified as described above, will handle 95,000 gpm with the water surface 10-ft. below the top of the downcomer, and 105,000 gpm with the water surface 4.75 feet below the top of the downcomer, indicating that there is adequate capacity to handle these two flows. For the 115,000 gpm flow condition Figure 5 shows the water surface in the downcomer to be immediately below its top. This is considered unsatisfactory and for this condition a new downcomer will be required.

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An analysis for 115,000 gpm flow, considering two downcomers plus a new 60 inch line 350 ft. long tying the new downcomer into the existing system, indicates that this flow can be handled. Because of the turbulence expected in the discharge box at the 107-F basin for the 105,000 gpm and 115,000 flow conditions it is recommended that a reinforced concrete cover be provided over the box.

Document GEH-24522 points out that in the existing effluent line immediately down stream from the downcomer it is likely that a hydraulic jump will exist. A pocket will be formed in the line between the hydraulic jump and the outlet from the downcomer because the hydraulic gradient is so low that the pressure in the pipe is below the vapor pressure of the water at 95° C. In order to obtain equilibrium conditions it is theorized that a positive pressure is developed in this pocket by pumping of vapor and air from the downcomer. This area of pressure will have an adverse effect on the capacity of the system and can be eliminated by venting the effluent system at this point. It is therefore recommended that this be done.

105-F Status of Modifications

In summary, this discussion of the structural and hydraulic characteristics of the 105-F downcomer and effluent line system assumes the following modifications will be made.

1. Installation of an elbow at the point of introduction of flow into the downcomer.
2. Perforation of all downcomer baffles.
3. Removal of the present downcomer baffle vent pipes.
4. Ventilation of the effluent line adjacent to the downcomers.
5. Reinforcing portions of the 105 Building structure containing the downcomer.

At the time of this writing it was planned that items 2 and 3 above would be done during the next shutdown. Therefore, these should not be considered a part of the work included in this study.

105-B Downcomer and Effluent Line System - Structural Study

SK-1-3842, Sheets 1 & 2 show effluent line and downcomer modifications proposed for B and C areas.

R. F. Jimenez's letter of April 15, 1957 reports that the 105-B downcomer can withstand heads of 20 ft. above the 0'0" elevation. This is equivalent to 38'-2-1/2" above the bottom of the downcomer. By perforating the downcomer baffles and removing the downcomer baffle vents, analysis indicates that the pressure in the downcomer at 115,000 gpm flow would be reduced to approximately 20 feet of head above the bottom of the downcomer. Since this is the maximum flow, no structural modifications will be required.

105-B Downcomer and Effluent Line Hydraulic Study

Assuming 115,000 gpm flow from 105-B and 10,000 gpm from 105-C, analysis indicates that the system is capable of handling the flow without pressurizing any junction boxes, if the downcomer is modified to improve its flow conditions. These modifications consist of:

1. Perforating the downcomer baffles.
2. Removing the downcomer baffle vent pipes.
3. Venting the effluent line adjacent to the downcomer.

Although calculations do not indicate formation of a pocket in the effluent line, the last of the above modifications should be made to eliminate the possibility of vapor and air from the downcomer forming such a pocket, and reducing the system capacity. This is particularly likely to happen at the area of reduced pressure downstream from the vena contracta of the downcomer discharge and especially at temperatures near boiling.

These modifications should be made for all flows above the existing rate, to improve flow conditions and reduce stresses.

105-C Downcomer and Effluent Line System Structural Study

Refer to SK-1-3842, Sheets 1 & 2.

The 105-C building has dual downcomers; at 115,000 gpm total, the flow through each will be 57,500 gpm. This is less than has been discharged previously through each downcomer when operating separately. The downcomer and the building structure are able to withstand a hydrostatic pressure head of 50 feet, which is twice that which the 105-F downcomer can withstand when reinforced as recommended by this report. Therefore, no structural modifications will be required to handle flows up to 115,000 gpm.

105-C Downcomer and Effluent Line Hydraulic Study

The most severe condition in the 105-C downcomer and effluent line system will occur when the system is handling a flow of 115,000 gpm from 105-C and a shutdown flow of 10,000 gpm. from 105-B, and the total flow is diverted to the 107-CE basin. This flow must be handled without raising the water surface above the height of the weirs in either the 105-C diversion box or the 105-B crossover box. For this condition analysis indicates that the height of the weirs at the diversion box would be exceeded although that at the crossover box would not. To rectify this it would be necessary to raise the diversion box weir height 5.5 ft. and its top 4.5 ft. For the 105,000 gpm flow condition a similar analysis indicates that the weir height must be raised 4 ft. and the top of the box 3 ft. In addition, the No. 2 60" x 60" sluice gate in the diversion box must be replaced by a 72" x 72" sluice gate. For the 95,000 gpm flow condition analysis indicates that no changes will be necessary other than those proposed by Study No. HW-61206.

DECLASSIFIED

DECLASSIFIED

HW-63487

Page 25

The system has also been checked to determine what modification, if any, are necessary to divert the 105-C shutdown flow of 10,000 gpm to the 105-B system through the 60" tie line from the 105-C diversion box, when the 105-B reactor is assumed to be discharging 115,000 gpm. Under this condition the water surface in the 105-C diversion box will be above the elevation of the weir proposed by Study HW-61206. However, with the weirs at the new elevations recommended above, this flow condition can be handled.

Since the flow per downcomer under the dual operation philosophy is less than has been handled in the past, no problem is expected with the downcomers and no modifications are recommended. However, at an operating temperature of 95° C with the possibility of excursions up to 100°C, it is considered desirable that the effluent lines adjacent to the downcomers be vented in order to avoid the formation of pockets in the lines which would reduce their capacity. This is particularly important in the near line which should operate with as few surges as possible to insure that the cross-tie to the 105-B system will operate effectively.

105-D Downcomer and Effluent Line System - General

Refer to SK-1-3847.

The 105-D downcomer and effluent line system consists of a single downcomer which discharges into a 66" line. Approximately 250 ft. from the 105-D building the 60 inch cross-tie line from the 105-D system joins the effluent line. The line extends approximately 1560 ft. to a box which is about 740 ft. from the 107-D basin. At this box the line size drops to 60". This line discharges over the wall of the 107-D basin through two 60 inch electrically operated gate valves. An emergency by-pass is provided to protect the system in the event both gate valves are inadvertently closed simultaneously.

105-D Downcomer and Effluent Line - Structural Study

R. F. Jimenez's letter of April 15, 1957 reports that the 105-D downcomer can withstand heads of 20 ft. above the 0'0" elevation. This is equivalent to 31'-2-1/2" above the bottom of the downcomer. The most severe loads will occur in the downcomer during the emergency condition that exists when the two 60 inch discharge gate valves have been simultaneously closed. In this condition all flow has to pass through the emergency by-pass and this backs the water up the system into the downcomer. Under this condition analysis shows that a pressure head in the downcomer of 30.40 feet exists. This is approximately equal to the allowable head in the downcomer and therefore no structural modifications are recommended.

105-D Downcomer and Effluent Line - Hydraulic Study

The maximum anticipated flow would exist when the 105-D Building is discharging 115,000 gpm and the 105-DR Building is discharging 10,000 gpm. Preliminary analysis indicates that under this condition the existing 60 inch line has inadequate capacity and would raise the water surface elevation in the 105-DR crossover box above the level of its weir; addition of a 48" line parallel to the 50 " line would lower the water surface elevations below the crossover box weir elevation. Therefore, it is recommended that this line be provided. Calculations indicate it is also necessary for the 105,000 gpm flow condition.

The existing piping system will handle the 95,000 gpm flow condition except that in this case the water surface elevation in the crossover boxes is high enough to warrant raising these boxes 3 feet.

For the emergency condition that exists when the two discharge gate valves are closed, analysis indicates that the system will handle any of the projected flows without backing the water surface in the downcomer above the 4th baffle, provided the baffles are perforated and the baffle vents are removed. Under this condition, however, the boxes in the effluent line will be pressurized by heads up to 12 feet and will therefore discharge water through any openings that exist, such as valve stem openings. Since this is an emergency condition it is considered that this is acceptable, although not desirable.

The calculations do not indicate the existence of a vapor trap or hydraulic jump in the line. However, at an effluent temperature of 95° C with a possibility of excursions to 100° C it is considered desirable that the effluent line be vented adjacent to the downcomer in order to release air and vapor that will be pumped in from the downcomer.

105-DR and 105-H Downcomers and Effluent Line System

Refer to SK-1-3847 for DR and Sk-1-3856 for H Reactor.

Both the 105-DR and 105-H downcomer and effluent line systems consist of dual downcomers and effluent lines. Analysis indicates that each has adequate capacity to handle flows up to 115,000 gpm without any modification. However, for operation near 100° C, the reasoning applied to the other areas makes it advisable to vent these lines adjacent to the downcomers. Therefore, this is recommended.

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H. Depressurization Stations

Two types of depressurization stations are considered briefly in this study. The first is for a bulk outlet effluent temperature of 95°C; the building and equipment arrangement are shown on Drawing SK-1-3819. The purpose of this station is to maintain enough rear face pressure to insure a back flow through any tube in case of a front pigtail failure, and thus prevent damage to the fuel elements and the process tube. No steam dissipation is required. This station would be located as near the 105 Building as practical; a typical location is shown on SK-1-3847.

The second type of depressurization station is for operation at bulk outlet temperatures above 100°C as shown on drawing SK-1-3841. Untreated river water at rates up to 30,000 gpm would be used to reduce the bulk temperature to 95°C to prevent flashing when the pressure is reduced to atmospheric.

Assuming a failure of quench water the reactor would be shutdown, but steam would be generated temporarily in the flash chamber and discharged up the short stack. Steam discharge would continue for 1 to 2 minutes, the time required to discharge the 105°C water in a long effluent line.

Considering the high transient rate of steam release, such a station should be located near the 107 basin.

With either type of pressure-reducing station, a new pressurized downcomer would be required on the reactor. Upstream pressure would be maintained by a battery of flash-flow type reducing valves that can handle a high pressure drop under flashing temperatures without damage to the valve. These valves would be controlled by upstream pressure during reactor operation and by level control in the top of the downcomer pipe during reactor shutdown operation.

These stations as shown are adequate for flows of 80,000 - 115,000 gpm.

I. Discussion of External vs. Immersion Temperature Detectors

Although this subject is not a primary factor in the present study, it deserves mention in connection with the proposal to change the rear-face fittings of B, D, DR, F and H reactors. In all these plants, the measurement of water temperature at the tube and outlets is by thermocouples which are mounted in wells extending into the flow streams.

Thermocouples with the same electrical characteristics are available with "wrap-around" mountings for application to the outside of a pipe or tube. Hence externally mounted sensing devices can be used if desirable without requiring changes in the read-out instruments.

The following advantages are foreseen for a change to external temperature detectors concurrently with the proposed replacement of fittings, since the changes would have to include the outlet nozzle assembly in which the thermocouple wells are now located.

1. The likelihood of leakage is less if wells can be avoided.
2. With proper mounting, the externally mounted thermocouple can respond at least as fast as the well-mounted one.
3. Even with larger fittings and lower water velocities, some pressure drop and turbulence are avoided if the flow channels are free of immersion wells.

This recommendation does not contemplate changing the zone temperature monitoring devices.

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HW-48519 Pressure, Flow and Temperature Responses to a Rapid Plugging of Process Tube. G. M. Hesson and W. L. Thorne. February 18, 1957. 27 p. CONFIDENTIAL

HW-48759 Boil-out Experiment. D. C. Pound. February 27, 1957. 22 p. CONFIDENTIAL

HW-48963 Change-Over to CG-600 Process Pumps. M. H. Schack. March 8, 1957. 3 p. SECRET

HW-49012 Effect of Outlet Temperature and Tube Corrosion on Hydraulic Demand Characteristics (of) Process Tubes. J. F. Calkins. March 18, 1957. 16 p. CONFIDENTIAL

HW-49440 105-D and 105-DR Trip Tests. W. A. Massena. March 28, 1957. 6 p. SECRET

HW-49570 Conditions Resulting From the Operation of Reduced Numbers of CG-558 - 190 Building Process Pumps. E. L. Etheridge and M. H. Schack. April 18, 1957. 10 p. SECRET

HW-49651 Reactor Flow Capabilities, K. W. Hess, April 17, 1957. 20 p. SECRET

HW-49813 Preliminary Experimental Results of Pressure and Temperature Response to Slow Plugging of a Process Tube. G. M. Hesson and W. L. Thorne. April 25, 1957. 11 p. CONFIDENTIAL

HW-49829 Summary of Low Pressure Mockup Test Data for the Period November 29 through December 4, 1956, Series VIII-A. W. L. Thorne and K. G. Toyoda. February 12, 1957. 37 p. CONFIDENTIAL

HW-49858 High Spot Report on Test Simulating the Response of the CG-558 Individual Process Tube System to Slow Plugging. L. H. McEwen. December 5, 1956. 3 p. CONFIDENTIAL

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HW-50104	Study of Water Pressure Requirements at Outlets of B, D and F Reactors. Post CG-558. E. F. Smith and D. W. McLenegan. May 6, 1957. 17 p. CONFIDENTIAL
HW-50323	Interim Report of Test Simulating the Transient Response of Individual Process Tubes to Inadvertent Plugging. J. M. Batch, G. M. Hesson, W. L. Thorne and K. G. Toyoda. May 24, 1957. 4 p. SECRET
HW-51327	Preliminary Analysis of Bulk Outlet Water Temperatures. S. S. Jones, 66 p. SECRET
Letter	April 15, 1957 to H. W. Heacock from R. F. Jimenez. Subject: Downcomer Pressurization Study.
HW-51769	Hydraulic Characteristics of Undersize "C" I&E Slugs in a C Process Tube. E. D. Waters. August 1, 1957. 3 p. CONFIDENTIAL
HW-51883	Experimental Plugging of Tube Inlet Screens. E. D. Waters. October 18, 1957. 23 p. CONFIDENTIAL
HW-51888	Experimental Pressure - Flow Characteristics of Process Tube Fittings with Simulated Plugging of Inlet Screens. G. M. Hesson and J. M. Batch. August 9, 1957. 12 p. CONFIDENTIAL
HW-52302	Critical Flow Conditions for B, D, F and DR Outlet Fittings. E. D. Waters and J. M. Batch. September 23, 1957. 12 p. SECRET
HW-52302 ADD	Critical Flow Conditions for B, D, F Outlet Fittings at High Flow Rates. E. D. Waters. January 2, 1958. 5 p. SECRET
HW-52424-A	Results of Experimental Tests Simulating Sudden Plugging of A,B, D, F Process Tube. J. M. Batch, G. M. Hesson and W. L. Thorne. September 23, 1957. 53 p. SECRET
HW-52424-B	Results of Experimental Tests Simulating Slow Plugging of A B, D, F Process Tube. G. M. Hesson and W. L. Thorne. October 14, 1957. 50 p. SECRET

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HW-52793 Reactor Bulk Outlet Temperature Limits, S. S. Jones, 3-6-58. 27 p. SECRET

HW-53379 Method for Empirical Calculation of Stability Limits K. W. Hess and S. M. Graves. November 12, 1957. 37 p. SECRET

HW-54146 Criticall Flow Conditions for K Reactor Outlet Fittings. E. D. Waters. 12-12-57, 20 p. SECRET

HW-54590 Standard Laboratory Hydraulic Pressure Drop Characteristics of Various Solid and I&E Fuel Elements. E. D. Waters and G. R. Horn. January 20, 1958. 23 p. CONFIDENTIAL

HW-55054 Process Tube Flow Rates with Low Front Header Pressure All Reactors. E. D. Waters. February 20, 1958. 10 p. CONFIDENTIAL

HW-55269 Laboratory Pressure Drop Data for Support Charges Using Pierced-Solid Dummy Slugs - All Reactors. E. D. Waters. March 7, 1958. 6 p. CONFIDENTIAL

HW-55282 Interim Report on Flow Hazard Experiments with I&E Fuel Elements in C Reactor. G. M. Hesson and D. E. Fitzsimmons. March 10, 1958. 10 p. SECRET

HW-55486 Proposal for Improved Control of Bulk Effluent Temperature Surges. S. S. Jones, 3-25-58. 4 p. CONFIDENTIAL DOCUMENTED

HW-55502 Instability Limits at Low Front Header Pressure C Reactor. F. W. Van Wormer. March 25, 1958. 7 p. SECRET

HW-55801 Bulk Outlet Temperature Limits and Increased Reactor Power Levels. S. S. Jones, June 13, 1958. 23 p. SECRET

HW-55937 Part I. Pressure Monitor and Panellit Gauges. Part II. Process Water Pressure Fluctuations. 100-B. Interim Report, Development Test IP-135-E. L. C. Cole and R. L. Roy. April 30, 1958. 14 p. UNCLASSIFIED.

HW-56099 Laboratory Pressure Drop Data for Support Charges Using Solid Aluminum Dummy Slugs. B, D, F and C Geometries. E. D. Waters. May 14, 1958. 5 p. CONFIDENTIAL

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HW-56142 Effectiveness of Outlet Water Temperature Monitors and Critical Flow Conditions for Outlet Fittings, C Reactor. E. D. Waters. May 26, 1958. 16 p. CONFIDENTIAL

HW-56428 Panellit Gage Oscillation Tests. 105-C. PT-IP-135-E. L. C. Cole and R. L. Roy. June 12, 1958. 7 p. UNCLASSIFIED

HW-56688 Maximum Flow Rate, C Reactor. F. W. Van Wormer. July 9, 1958. 5 p. CONFIDENTIAL

HW-57091 Project Costs for Five Year Existing Reactor Program. A. B. Carson and H. W. Heacock, 8-12-58. 8 p. SECRET

HW-57351 Critical Flow Conditions for B, D, F and DR Outlet Fittings Using a Slip-Joint Type Pigtail. E. D. Waters. September 5, 1958. 6 p. SECRET

HW-57547 Existing Reactor Modification Program Costs D, DR, and F Reactors. D. F. Watson. September 24, 1958. 6 p. CONFIDENTIAL

HW-57616 Experimental Results of Test of Simulating Plugging of a C Tube Charged with I&E Fuel Elements. G. M. Hesson, D. E. Fitzsimmons and J. E. Hammond. October 1, 1958. 15 p. SECRET

HW-58096 Hydraulic Characteristics of Self-Supported I&E Elements in a Ribless B, D, F, Process Tube. E. D. Waters and J. E. Hammond. November 7, 1958. 4 p. CONFIDENTIAL

HW-58453 Critical Flow Conditions and Temperature Monitor Effectiveness H Reactor Outlet Fittings (with Helical, Slip-Joint, or Ruptured Pigtails) E. D. Waters. December 10, 1958. 9 p. SECRET

HW-58580 Existing Reactor Water Plant Study B, C, D, DR, F, H Reactors Interim Report. D. F. Watson, 1-19-59. 41 p. SECRET

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HW-59017 Part 1	Budget Study Report - FY - 1961 Plant Acquisition and Construction Budget Effluent System Modifications to Increase Bulk Outlet Temperatures B, F, D, DR, H and C Reactors. E. R. Rudock, 2-2-59. 20 p. SECRET
HW-59017 Part 2	Budget Study Report - FY - 1961 Plant Acquisition and Construction Budget - Effluent System Modifications to Increase Bulk Outlet Temperatures KE and KW Reactors. E. R. Rudock 2-2-59. 11 p. SECRET
HW-59670	Second Performance Test of CG-558. 190 Building Pump with Replacement Rotating Assembly. N. F. Fifer and M. H. Schack, 3-16-59. 4 p. UNCLASSIFIED
HW-59830	Performance Test of CG-558 190 Building Pump with Replacement Rotating Assembly, N. F. Fifer and M. H. Schack, 3-31-59. 4 p. UNCLASSIFIED
HW-59900	Rear Face Crossunder Lines at B, D, DR, F, and H Reactors Scope and Justification. E. J. Kempf June 16, 1959. 21 p. SECRET
HW-60164	Results on Reverse Flow Experimental Tests for C Operational Charge-Discharge Tube at Low Tube Powers. D. E. Fitzsimmons and G. M. Hesson. April 30, 1959. 13 p. SECRET
HW-60287	Interim Report on Laboratory Experiments Investigating Consequences of Failure of Front Hydraulic Fittings in "C" OCD Geometry. D. E. Fitzsimmons and G. M. Hesson. May 6, 1959. 12 p. SECRET
HW-60596	Existing Reactor Expansion Study Basis, H. W. Heacock, 6-24-59. 20 p. SECRET
HW-60864	DR Reactor Bulk Temperature Program. S. S. Jones. 6-17-59. 48 p. CONFIDENTIAL

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HW-60899	Final Report on Design Tests PR-50 and PR-51 Reactor Piping Seal Testing and Reactor Piping Structural Integrity. P. M. Jackson, 6-26-59. 58 p. UNCLASSIFIED
HW-60997	Project CG-775 Representatives Meeting No. 4 June 16, 1959. H. W. Heacock. 9-28-59. 7 p. SECRET
HW-61030	Existing Reactor Expansion Program, Technical Uncertainties. H. W. Heacock, 7-8-59. 7 p. CONFIDENTIAL
HW-61456	Production Test IP-278-A - Verification of Transient Bulk Temperature Surges at the DR Reactor. S. S. Jones. August 18, 1959 10 p. SECRET
HW-61456 App	Detail Procedures for the Verification of Bulk Temperature Surges of the DR Reactor. S. S. Jones, 8-18-59. 16 p. UNCLASSIFIED
HW-61754	Eight Pump Operation. R. W. Ried, 9-2-59. 2 p. SECRET
HW-61925	Calculation of K Reactor Flow Decay Transient W. A. Massena, September 17, 1959. 15 p. SECRET
Letter	October 13, 1959 to H. W. Heacock from F. J. Kempf. Crossheader Fitting Inspection at B Reactor
HW-62010	C Reactor Water Plant Capabilities. E. E. Leitz September 21, 1959. 6 p. SECRET
HW-62113	A Method of Controlling Reactor Power Surges to Permit a Bulk Outlet Temperature Limit Increase. J. F. Music, September 29, 1959. 2 p. SECRET
HW-62180	Critical Flow at Outlet Fittings, B, D, F Reactors D. W. McLenegan 10-5-59. 4 p. SECRET
HW-62729	Flow Conditions at Outlet Fittings of Hanford Reactors. D. W. McLenegan, 11-12-59. 10 p. SECRET
HW-62813	Expansion Program 190 Building Studies Results. C. F. Quackenbush, 11-25-59. 5 p. SECRET
Letter	Dec. 28, 1959. By E. C. Wood, R. M. Smithers. Subject: Rear Crossheader Cavitation and Flow Investigation.
SSN/551(551B)	Tentative Structural Design Basis for Reactor Vessels. James L. Merschon. April 1, 1958.

VII APPENDIXSUPPORTING DATA AND DRAWINGS

In addition to the following tables and the reference list of technical reports, the original calculations supporting this report are filed under: "HW-63581 - Piping Changes for Increased Production at B, D, DR, F, C and H Reactors, Calculations".

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TABLE I

RECOMMENDED PIPING SIZES AT INCREASED FLOWS FOR
95° C BULK EFFLUENT TEMPERATURE AT B, D, AND F REACTORS

Description	Existing Size	Sizes Required for Following Flows				
		80,000	95,000	105,000	115,000	150,000
Valve Pit Manifold	36"					50"
Valve Pit to Riser Pipe	36"					44"
Riser, Inlet	36"					44"
Crossheader Loop Inlet	5" Sch. 80					6" Sch. 80
Crossheader Strainer and Check	5" -400#					6" -400#
Crossheader Gate Valve	4" -300#		5" -400#	6" -400#		
Crossheader Manifold Inlet	4" Sch. 40					5" Sch. 40
Crossheader Fitting Inlet	5/8" Tube		1" Tube			
Crossheader Fitting Outlet	5/8" Tube	1" Tube				
Crossheader Manifold Outlet	4" Sch. 40		4" Sch. 20		5" Tube	
Crossheader Loop Outlet	4" Sch. 40	5" Tube			6" Tube	
Riser, Outlet	36" 3/16" Wall	42" 5/16" Wall		48" 1/16" Wall		
Riser Support Outlet	Fixed	Roller Type - to allow risers to move				
Crossheader Pipe Outlet	None	12" & 24" at B & D; (2) 12" at F See Dwg. SK-1-3821 & 22				
Crossover Pipe Outlet	36" 3/16" Wall					
Crossover to Down- comer	42" 3/16" Wall	60" 7/16" Wall		(2) 48" 5/16" Wall		

TABLE II

RECOMMENDED PIPE SIZES AT INCREASED FLOWS FOR 95°C
BULK EFFLUENT TEMPERATURE AT DR & H REACTORS

Description	Existing Size	Sizes Required for Following Flows				
		80,000	95,000	105,000	115,000	150,000
Valve Pit Manifold	36" at DR None at H					50" at DR
Valve Pit to Riser Pipe	36" at DR (2) 24" at H					44" at DR
Riser, Inlet	36"					44"
Crossheader Loop Inlet	6" Sch. 80 every other row	6" Sch. 80 5" Sch. 80 Alternate rows				6" Sch. 80 Every row
Crossheader Strainer and Check	6" 400# every other row	6" 400# 5" 400# Alternate rows				6" 400# Every row
Crossheader Gate Valve	6" 400# every other row	6" 400# 5" 400# Alternate rows				6" 400# Every row
Crossheader Mani- fold Inlet	4" Sch. 40 Every other row	4" Sch. 40 Every row				5" Sch. 40 Every row
Crossheader Fitting Inlet	5/8" Tube	1" Tube				
Crossheader Fitting Outlet	5/8" Tube	1" Tube				
Crossheader Mani- fold Outlet	4" Sch. 40 Every other row	4" Sch. 20 Every row				5" Tube Every row
Crossheader Loop Outlet	4" Sch. 40 Every other row	5" Tube Every row				6" Tube Every row
Riser, Outlet	36" 3/16" wall	42" 5/16" Wall				48" 3/16" Wall
Riser Support Outlet	Fixed	Roller Type to allow riser to move				
Crossheader Pipe Outlet	None	2-20" at DR; 16" & 24" at H; See Dwg. SK-1-3823 & 23				
Crossover Pipe Outlet	36" 3/16" Wall					
Crossover to Downcomer	42" 3/16" Wall	42" 5/16" Wall				48" 5/16" Wall

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TABLE III

RECOMMENDED PIPING SIZES AT INCREASED FLOWS
FOR 95°C BULK EFFLUENT TEMPERATURE AT C REACTOR

Description	Existing Size	Size Required for Following Flows			
		95,000	105,000	115,000	150,000
190 Bldg. to Riser	(3) 24"				
Riser, Inlet	(2) 30"				
Crossheader Loop, Inlet	5" Sch. 80				
Crossheader Strainer & Check	5" 400#				6" Sch. 80
Crossheader Gate Valve	5" 400#				6" 400#
Crossheader Manifold, Inlet	4" Sch. 40				6" 400#
Crossheader Fitting, Inlet	5/8" Tube				5" Sch. 40
Crossheader Fitting Outlet	1" Tube				1" Tube
Crossheader Manifold Outlet	4" Sch. 40				5" Tube
Crossheader Loop & Valves Outlet	4" Sch. 40				6" Tube
Riser, Outlet	36" 1/2" Wall				48" 5/16 Wall
Riser Support, Outlet	Fixed	Roller type to allow riser to move			
Crossunder Pipe, Outlet	None required	with continuous charge discharge			
Crossover Pipe, Outlet	36" 1/2" Wall				
Crossover to Downcomer	54" 1/2" Wall				

4. Recommendations to attain Increased Power at 105°C Bulk Effluent Temperature.

The following tabular data shows the changes required to pressurize the reactors to operate at above boiling effluent temperatures.

The front face changes are the same for each flow as for operation at 95°C.

The principal change on the rear face is the need for a pressurized downcomer pipe rather than using the existing cascade type downcomers.

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TABLE IV

Recommended Downcomer & Effluent Line Modifications For 95°C Bulk Temperature

Summary

<u>Area</u>	<u>Modification</u>	<u>FLOW*</u>			
		<u>Existing</u>	<u>Cond. I</u>	<u>Cond. II</u>	<u>Cond. III</u>
100-B	1. Perforate downcomer baffles		x	x	x
	2. Remove downcomer vents		x	x	x
	3. Vent effluent line adjacent to downcomer		x	x	x
100-C	1. Modifications to diversion box at N 70595; W80156				
	a. replace No. 2 gate w/72x72" gate			x	x
	b. raise elevation of weir 4.0			x	
	c. raise top of box 3 ft.			x	
	d. raise elevation of weirs 5.50 ft.				x
	e. raise top of box 4.5 ft.				x
	2. Vent effluent lines adjacent to downcomers		x	x	x
100-D	1. Perforate downcomer baffles		x	x	x
	2. Remove downcomer vents		x	x	x
	3. Vent effluent line adjacent to downcomer		x	x	x
	4. Raise crossover boxes at N 92524; W52675 and N92524; W 52410 3 ft.		x		
	5. Add 48" line between 107-D basin & junction box at N 93825; W 52741			x	x
100-DR	No modifications required except venting effluent lines adjacent to the downcomers.				
100-F	1. Reinforce bottom 15' of wall between downcomer and riser space		x	x	x
	2. Add downcomer elbow		x	x	x
	3. Vent effluent line adjacent to downcomer		x	x	x
	4. Add new downcomer				x
	5. Add 350' of 60" effluent line				x
	6. Cover discharge box at 107 basin			x	x
100-H	No modifications required except venting effluent lines adjacent to the downcomers.				

* Cond I = 95,000 gpm
Cond II = 105,000 gpm
Cond III = 115,000 gpm

For 105-C Cond. I is existing condition. All flows are at temperature of 95°C.

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TABLE V
RECOMMENDED PIPE SIZES AT INCREASED FLOWS FOR 105°C
BULK EFFLUENT TEMPERATURE AT B, D, F REACTORS

Description	Existing Size	Sizes Required for Following Flows				
		80,000	95,000	105,000	115,000	150,000
Valve Pit Manifold	36"					50"
Valve Pit to Riser Pipe	36"					44"
Riser, Inlet	36"					44"
Crossheader Loop, Inlet	5" Sch. 80					6" Sch. 80
Crossheader Strainer & Check	5" 400#					6" 400#
Crossheader Gate Valve	4" 300#	5" 400#		6" 400#		
Crossheader Manifold Inlet	4" Sch. 40					5" Sch. 40
Crossheader Fitting Inlet	5/8" Tube	1" Tube				
Crossheader Fitting Outlet	5/8" Tube	1" Tube				
Crossheader Manifold Outlet	4" Sch. 40	4" Sch. 20		5" Tube		
Crossheader Loop & Valves Outlet	4" Sch. 40	5" Tube		6" Tube		
Riser, Outlet	36" 3/16" Wall	42" 5/16" Wall		48" 5/16" Wall		
Riser Support Outlet	Fixed	Roller type to allow risers to move				
Crossunder Pipe, Outlet	None	12" & 24" at B & D, (2) 12" at F, See Dwg. SK-13813 & 14				
Crossover Pipe, Outlet	36" 3/16" Wall	42" 5/16" Wall		48" 5/16" Wall		
Crossover to Downcomer	42" 3/16" Wall	48" 7/16" Wall		54" 1/16" Wall		
Downcomer	One Cascade Type; New	48" 7/16" Wall Downcomer Pipe				54" 7/16" Wall
Energy Dissipator	None	Provide as per Drawing SK-1-3841				
Quench Water Req'd. GPM	None	12,000	14,000	15,000	18,000	22,000
Effluent Line Pressurized	None	48" 7/16" Wall		54" 7/16" Wall		

TABLE VI

RECOMMENDED PIPE SIZES AT INCREASED FLOWS FOR 105°C
BULK EFFLUENT TEMPERATURE AT DR & H REACTORS

Description	Existing Size	Sizes Required for Following Flows				
		80,000	95,000	105,000	115,000	150,000
Valve Pit Manifold	36" at DR None at H					50"
Valve Pit to Riser Pipe	36" at DR 2 24" at H			2 30" at H		44"
Riser, Inlet	36"					44"
Crossheader Loop Inlet	6" Sch. 80 Every Other Row		5" Sch. 80 Alt. Rows			6" Sch 80 6" Sch 80
Crossheader Strainer & Check	6" 400# Every Other Row		5" 400# Alt. Rows			6" 400# 6" 400#
Crossheader Gate Valve	6" 400# Every Other Row		5" 400# Alt. Rows			6" 400# 6" 400#
Crossheader Manifold Inlet	4" Sch. 40 Every Other Row		4" Sch. 40 Every Row			5" Sch 40 Every Row
Crossheader Fitting Inlet	5/8" Tube		1" Tube			
Crossheader Fitting, Outlet	5/8" Tube	1" Tube				
Crossheader Manifold Outlet	4" Sch. 40 Every Other Row	4" Sch. 20 Every Row				5" Tube Every Row
Crossheader Loop & Valves Outlet	4" Sch. 40 Every Other Row	5" Tube Every Row				6" Tube Every Row
Riser, Outlet	36" 3/16" Wall	42" 5/16" Wall		48" 5/16" Wall		
Riser Support, Outlet	Fixed	Roller type to allow riser to move				
Crossunder Pipe Outlet	None	2 24" at DR 16" & 24" at H	See Dwg. SK-1-3815, 16, 17 and 18			
Crossover Pipe, Outlet	36" 3/16" Wall	42" 5/16" Wall		48" 5/16" Wall		
Crossover to Downcomer	42" 3/16" Wall	48" 7/16" Wall				54" 7/16" Wall
Downcomer	Two Cascade Type	New 48" 7/16" Wall Downcomer Pipe				54" 7/16" Wall
Effluent Line (Pressurized)	None	48" 7/16" Wall				54" 7/16" Wall
Quench Water Req'd. GPM	None	12,000	14,000	15,000	18,000	22,000

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TABLE VII

RECOMMENDED PIPE SIZES AT INCREASED FLOWS FOR 105°C
BULK EFFLUENT TEMPERATURE AT "C" REACTOR

Description	Existing Size	Sizes Required for Following Flows			
		95,000	105,000	115,000	150,000
190 Bldg. to Riser	(3) 24" _____→				
Riser, Inlet	(2) 30" _____→				
Crossheader Loop Inlet	5" Sch. 80 _____→				6" Sch. 80
Crossheader Strainer & Check	5" 400# _____→				6" 400#
Crossheader Gate Valve	5" 400# _____→				6" 400#
Crossheader Manifold, Inlet	4" Sch. 40 _____→				5" Sch. 40
Crossheader Fitting, Inlet	5/8" Tube _____→	1" Tube _____→			
Crossheader Fitting Outlet	1" Tube _____→				
Crossheader Manifold Outlet	4" Sch. 40 _____→				5" Tube
Crossheader Loop & Valve Outlet	4" Sch. 40 _____→				6" Tube
Riser, Outlet	36" 1/2" Wall _____→				48" 5/16" Wall
Riser Support, Outlet	Fixed	Roller type to allow riser to move _____→			
Crossunder Pipe, Outlet	None	None required with continuous charge discharge			
Crossover Pipe, Outlet	36" 1/2" Wall _____→				48" 5/16" Wall
Crossover to Downcomer	54" 1/2" Wall _____→				
Downcomer	Two Cascade Type	One 54" 1/2" Wall, Pressurized Downcomer Pipe			
Effluent Line (Pressurized)	None	48" 7/16" Wall _____→			54" 7/16" Wall
Energy Dissipator	None	Provide as per Drawing SK-1-3841 _____→			
Quench Water Req'd. GPM	None	14,000	15,000	18,000	22,000

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RECOMMENDED PIPING SIZES AT INCREASED FLOWS FOR 95°C & 105°C. (SEE DOCUMENT FOR DETAILS AT 15°, 20° & 25° FLOWS)				RECOMMENDED PIPING SIZES AT INCREASED FLOWS FOR 95°C & 105°C. (SEE DOCUMENT FOR DETAILS AT 15°, 20° & 25° FLOWS)				RECOMMENDED PIPING SIZES AT INCREASED FLOWS FOR 95°C & 105°C. (SEE DOCUMENT FOR DETAILS AT 15°, 20° & 25° FLOWS)			
NO.	DESCRIPTION	EXISTING SIZE	SIZE REQUIRED FOR FOLLOWING FLOWS	EXISTING SIZE	SIZE REQUIRED FOR FOLLOWING FLOWS	EXISTING SIZE	SIZE REQUIRED FOR FOLLOWING FLOWS	EXISTING SIZE	SIZE REQUIRED FOR FOLLOWING FLOWS	EXISTING SIZE	SIZE REQUIRED FOR FOLLOWING FLOWS
1	CROSSOVER PIPE	36"	50"	36"	50"	36"	50"	36"	50"	36"	50"
2	OUTLET LOOP & VALVES	36"	44"	36"	44"	36"	44"	36"	44"	36"	44"
3	OUTLET RISER	36"	44"	36"	44"	36"	44"	36"	44"	36"	44"
4	OUTLET LOOP	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40
5	DOWNCOMER	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40
6	CROSSOVER PIPE	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40
7	CROSSOVER PIPE	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40
8	CROSSOVER PIPE	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40	5" SCH 40	6" SCH 40

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RECOMMENDED PIPING SIZES AT INCREASED FLOWS EXISTENT TEMPERATURES AT 15°, 20° & 25° F			
NO.	DESCRIPTION	EXISTING SIZE	SIZE REQUIRED FOR 20,000 93,000 1%
1	CROSSOVER FITTING	9" TUBE	1" TUBE
2	CROSSOVER OUTLET	4" SCH 40	4" SCH 20
3	OUTLET LOOP & VALVES	4" SCH 40	6" TUBE
4	OUTLET RISER	36" 1/2" WALL	45" 1/2" WALL
5	RISER SUPPORT	FLANGE	ROLLER TYPE - TO ALL
6	CROSSOVER PIPE	NAME	12" 24" IN 5' 6" D, 2-12"
7	CROSSOVER PIPE	36" 1/2" WALL	
8	CROSSOVER TO DOWNCOMER	45" 1/2" WALL	60" 1/2" WALL
9	DOWNCOMER	ONE LBS. CAP. TYPE	SEE DOCUMENT
10	EFFLUENT LINE	60" IN F	SEE DOCUMENT

Flow Rate (GPM)	Flow Rate (GPM)
100,000	100,000
110,000	110,000
120,000	120,000
130,000	130,000
140,000	140,000
150,000	150,000
160,000	160,000
170,000	170,000
180,000	180,000
190,000	190,000
200,000	200,000
210,000	210,000
220,000	220,000
230,000	230,000
240,000	240,000
250,000	250,000
260,000	260,000
270,000	270,000
280,000	280,000
290,000	290,000
300,000	300,000
310,000	310,000
320,000	320,000
330,000	330,000
340,000	340,000
350,000	350,000
360,000	360,000
370,000	370,000
380,000	380,000
390,000	390,000
400,000	400,000
410,000	410,000
420,000	420,000
430,000	430,000
440,000	440,000
450,000	450,000
460,000	460,000
470,000	470,000
480,000	480,000
490,000	490,000
500,000	500,000
510,000	510,000
520,000	520,000
530,000	530,000
540,000	540,000
550,000	550,000
560,000	560,000
570,000	570,000
580,000	580,000
590,000	590,000
600,000	600,000
610,000	610,000
620,000	620,000
630,000	630,000
640,000	640,000
650,000	650,000
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670,000	670,000
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690,000	690,000
700,000	700,000
710,000	710,000
720,000	720,000
730,000	730,000
740,000	740,000
750,000	750,000
760,000	760,000
770,000	770,000
780,000	780,000
790,000	790,000
800,000	800,000
810,000	810,000
820,000	820,000
830,000	830,000
840,000	840,000
850,000	850,000
860,000	860,000
870,000	870,000
880,000	880,000
890,000	890,000
900,000	900,000
910,000	910,000
920,000	920,000
930,000	930,000
940,000	940,000
950,000	950,000
960,000	960,000
970,000	970,000
980,000	980,000
990,000	990,000
1,000,000	1,000,000

REAR FACE
GRAVITY FLOW

THIS DOCUMENT CONTAINS UNCLASSIFIED DATA
AS DEFINED IN THE ATOMIC ENERGY ACT OF
1954, ITS TRANSFER TO THE PUBLIC OR THE
DISCLOSURE OF ITS CONTENTS IN ANY MANNER TO AN
UNAUTHORIZED PERSON IS PROHIBITED.

Flow Rate (GPM)	Flow Rate (GPM)	Flow Rate (GPM)	Flow Rate (GPM)
100,000	100,000	100,000	100,000
110,000	110,000	110,000	110,000
120,000	120,000	120,000	120,000
130,000	130,000	130,000	130,000
140,000	140,000	140,000	140,000
150,000	150,000	150,000	150,000
160,000	160,000	160,000	160,000
170,000	170,000	170,000	170,000
180,000	180,000	180,000	180,000
190,000	190,000	190,000	190,000
200,000	200,000	200,000	200,000
210,000	210,000	210,000	210,000
220,000	220,000	220,000	220,000
230,000	230,000	230,000	230,000
240,000	240,000	240,000	240,000
250,000	250,000	250,000	250,000
260,000	260,000	260,000	260,000
270,000	270,000	270,000	270,000
280,000	280,000	280,000	280,000
290,000	290,000	290,000	290,000
300,000	300,000	300,000	300,000
310,000	310,000	310,000	310,000
320,000	320,000	320,000	320,000
330,000	330,000	330,000	330,000
340,000	340,000	340,000	340,000
350,000	350,000	350,000	350,000
360,000	360,000	360,000	360,000
370,000	370,000	370,000	370,000
380,000	380,000	380,000	380,000
390,000	390,000	390,000	390,000
400,000	400,000	400,000	400,000
410,000	410,000	410,000	410,000
420,000	420,000	420,000	420,000
430,000	430,000	430,000	430,000
440,000	440,000	440,000	440,000
450,000	450,000	450,000	450,000
460,000	460,000	460,000	460,000
470,000	470,000	470,000	470,000
480,000	480,000	480,000	480,000
490,000	490,000	490,000	490,000
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510,000	510,000	510,000	510,000
520,000	520,000	520,000	520,000
530,000	530,000	530,000	530,000
540,000	540,000	540,000	540,000
550,000	550,000	550,000	550,000
560,000	560,000	560,000	560,000
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580,000	580,000	580,000	580,000
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640,000	640,000	640,000	640,000
650,000	650,000	650,000	650,000
660,000	660,000	660,000	660,000
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720,000	720,000	720,000	720,000
730,000	730,000	730,000	730,000
740,000	740,000	740,000	740,000
750,000	750,000	750,000	750,000
760,000	760,000	760,000	760,000
770,000	770,000	770,000	770,000
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790,000	790,000	790,000	790,000
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830,000	830,000	830,000	830,000
840,000	840,000	840,000	840,000
850,000	850,000	850,000	850,000
860,000	860,000	860,000	860,000
870,000	870,000	870,000	870,000
880,000	880,000	880,000	880,000
890,000	890,000	890,000	890,000
900,000	900,000	900,000	900,000
910,000	910,000	910,000	910,000
920,000	920,000	920,000	920,000
930,000	930,000	930,000	930,000
940,000	940,000	940,000	940,000
950,000	950,000	950,000	950,000
960,000	960,000	960,000	960,000
970,000	970,000	970,000	970,000
980,000	980,000	980,000	980,000
990,000	990,000	990,000	990,000
1,000,000	1,000,000	1,000,000	1,000,000

DECLASSIFIED

SK-1-3812

7 2

U. S. ATOMIC ENERGY COMMISSION

MANFORD ATOMIC PRODUCTS OPERATION

GENERAL ELECTRIC

PROCESS PIPING

FLOW SHEET

SK-1-3812

1 2

NOTE:
SEE DWG. SK-1-3812 SHTS. 1 & 2
FOR DELINEATION OF NEW WORK.

REVISIONS		REV.	DATE	BY
NONE				
SK-1-3826				
SCALE NOTED		APPROVALS		
DESIGNED BY T. D. [Signature]		DATE		
CHECKED BY [Signature]		DATE		
U.S. ATOMIC ENERGY COMMISSION				
SANDHURST ATOMIC PRODUCTS OPERATION				
GENERAL ELECTRIC				
PROCESS PIPING				
TYP FRONT FACE				
ARRANGEMENT				
REFRATOR INCREASED PRODUCTION				
105 B. D. F				
SK-1-3826				

H-1-26768 FRONT FACE ARRG	
REV. NO.	REVISIONS
1	105 B. D. F

X-HEADERS* DRAIN
JWG#P-1317 FOR 105-H)
JWG #H-1-8317-DR FOR 105-DR)
TH 2" DRAIN
DERS DO NOT HAVE DRAINS
DERS

DETAIL "X"

2 - FEEDER CONNS
TO OPP. SIDE

NOTES:

1. REFER TO DWG H-1-26406 FOR DETAIL OF PIPING TO LOOP HEADER
2. REFER TO DWG SK-1-3866 FOR DETAIL OF X-HEADER TO TUBE INLET
3. THE DRAWING TYPICAL FOR 105 DR & M ON WORK SHOWN FOR "C" IS ON DETAIL "X"
4. SEE DWG. SK-1-3812, SHTS. 182 FOR DELINEATION OF NEW WORK.

P-8451	INLET PIPING ARR'G'T
54-1-2026	FRONT FACE ARR'G'T
H-12608	FRONT FACE ARR'G'T
H-397704	FRONT FACE ARR'G'T (105 DEG)
P-4849	FRONT FACE ARR'G'T (105W)
DATE	ISSUING OFFICE
BY	REFERENCE DRAWINGS
REVISIONS	

CLASSIFICATION						REV OF DATE		APPRO BY		FOR DATE	
REVISIONS CLASSIFICATION								CLASSIFIED BY <i>S.K. Peltz</i>			
NONE								DATE 11-19-87			
= SK-I-3827 - - o						GROUP NO.		PAGE		TOTAL PGS	
SCALE NOTED						APPROVAL					
DESIGN I.J. DATE 11-23-87						BY <i>M. J. ...</i> FOR <i>J. ...</i>					
DRAWING DATE						DATE 1-20-88					
<i>at</i> DATE 1-2-88											
CNSL. MARGIT UNIT PM											
UNIT 10554											
DO-1121											
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC											
PROCESS PIPING TYP. FRONT FACE ARRANGEMENT											
REACTOR INCREASED PRODUCTION											
R-105 DR. H & C						S&O/					
= SK-I-3827

N-REAR FACE 105 B'D & F REACTOR

SECTION THRU PROCESS HEADERS

NOTE:
SEE DWG. SK-1-3812 SMT. 1 FOR
DELINEATION OF NEW WORK.

REVISIONS		DATE	BY	CHKD	APP'D
NONE					
SK-1-3821		APPROVAL			
SCALE 1/8" = 1'-0"		DATE 11/10/60			
DRAWN BY J. D. WITT		CHECKED BY J. D. WITT			
DATE 10/1/60		DATE 11/10/60			
DESIGNED BY J. D. WITT		DATE 10/1/60			
NO. 10534		DATE 10/1/60			
PROJECT DO-1121		DATE 10/1/60			
U. S. ATOMIC ENERGY COMMISSION					
SANDHURST ATOMIC PRODUCTS OPERATION					
GENERAL ELECTRIC					
PROCESS PIPING					
REAR FACE					
GRAVITY FLOW					
SK-1-3821		DATE 11/10/60			

ITEM NO.	DESCRIPTION
1	REAR FACE 105 B'D & F REACTOR
2	NEW 4" CROSS HEADERS
3	NEW 4" DOWNCOMER PIPES
4	NEW 4" RISES
5	NEW 4" DRAINS
6	NEW 4" SUPPORTS
7	NEW 4" 18" DIA. RED
8	NEW 4" 18" DIA. RED
9	NEW 4" 18" DIA. RED
10	NEW 4" 18" DIA. RED
11	NEW 4" 18" DIA. RED
12	NEW 4" 18" DIA. RED
13	NEW 4" 18" DIA. RED
14	NEW 4" 18" DIA. RED
15	NEW 4" 18" DIA. RED
16	NEW 4" 18" DIA. RED
17	NEW 4" 18" DIA. RED
18	NEW 4" 18" DIA. RED
19	NEW 4" 18" DIA. RED
20	NEW 4" 18" DIA. RED
21	NEW 4" 18" DIA. RED
22	NEW 4" 18" DIA. RED
23	NEW 4" 18" DIA. RED
24	NEW 4" 18" DIA. RED
25	NEW 4" 18" DIA. RED
26	NEW 4" 18" DIA. RED
27	NEW 4" 18" DIA. RED
28	NEW 4" 18" DIA. RED
29	NEW 4" 18" DIA. RED
30	NEW 4" 18" DIA. RED
31	NEW 4" 18" DIA. RED
32	NEW 4" 18" DIA. RED
33	NEW 4" 18" DIA. RED
34	NEW 4" 18" DIA. RED
35	NEW 4" 18" DIA. RED
36	NEW 4" 18" DIA. RED
37	NEW 4" 18" DIA. RED
38	NEW 4" 18" DIA. RED
39	NEW 4" 18" DIA. RED
40	NEW 4" 18" DIA. RED
41	NEW 4" 18" DIA. RED
42	NEW 4" 18" DIA. RED
43	NEW 4" 18" DIA. RED
44	NEW 4" 18" DIA. RED
45	NEW 4" 18" DIA. RED
46	NEW 4" 18" DIA. RED
47	NEW 4" 18" DIA. RED
48	NEW 4" 18" DIA. RED
49	NEW 4" 18" DIA. RED
50	NEW 4" 18" DIA. RED
51	NEW 4" 18" DIA. RED
52	NEW 4" 18" DIA. RED
53	NEW 4" 18" DIA. RED
54	NEW 4" 18" DIA. RED
55	NEW 4" 18" DIA. RED
56	NEW 4" 18" DIA. RED
57	NEW 4" 18" DIA. RED
58	NEW 4" 18" DIA. RED
59	NEW 4" 18" DIA. RED
60	NEW 4" 18" DIA. RED
61	NEW 4" 18" DIA. RED
62	NEW 4" 18" DIA. RED
63	NEW 4" 18" DIA. RED
64	NEW 4" 18" DIA. RED
65	NEW 4" 18" DIA. RED
66	NEW 4" 18" DIA. RED
67	NEW 4" 18" DIA. RED
68	NEW 4" 18" DIA. RED
69	NEW 4" 18" DIA. RED
70	NEW 4" 18" DIA. RED
71	NEW 4" 18" DIA. RED
72	NEW 4" 18" DIA. RED
73	NEW 4" 18" DIA. RED
74	NEW 4" 18" DIA. RED
75	NEW 4" 18" DIA. RED
76	NEW 4" 18" DIA. RED
77	NEW 4" 18" DIA. RED
78	NEW 4" 18" DIA. RED
79	NEW 4" 18" DIA. RED
80	NEW 4" 18" DIA. RED
81	NEW 4" 18" DIA. RED
82	NEW 4" 18" DIA. RED
83	NEW 4" 18" DIA. RED
84	NEW 4" 18" DIA. RED
85	NEW 4" 18" DIA. RED
86	NEW 4" 18" DIA. RED
87	NEW 4" 18" DIA. RED
88	NEW 4" 18" DIA. RED
89	NEW 4" 18" DIA. RED
90	NEW 4" 18" DIA. RED
91	NEW 4" 18" DIA. RED
92	NEW 4" 18" DIA. RED
93	NEW 4" 18" DIA. RED
94	NEW 4" 18" DIA. RED
95	NEW 4" 18" DIA. RED
96	NEW 4" 18" DIA. RED
97	NEW 4" 18" DIA. RED
98	NEW 4" 18" DIA. RED
99	NEW 4" 18" DIA. RED
100	NEW 4" 18" DIA. RED

REVISIONS		DATE	BY
NONE			
SK-1-3822			
SCALE: 1" = 1'-0"		DRAWN BY: [Signature]	
CHECKED BY: [Signature]		DATE: 10/5/54	
U. S. ATOMIC ENERGY COMMISSION		GENERAL ELECTRIC	
HANFORD ATOMIC PRODUCTS OPERATION			
PROCESS PIPING			
REAR FACE			
GRAVITY FLOW			
REACTOR INSULATED PROTECTION			
105 B40			
SK-1-3822

NOTES:
 1. SEE DWG. SK-1-3823, PLAN, FOR
 2. SEE DWG. SK-1-3811, INT. FOR
 3. DELINEATION OF NEW WORK
 4. SEE DWG. SK-1-3823, FOR HEADERS
 5. TO DEMONSTRATE

REVISIONS		DATE	BY	APP'D	FOR	DATE
NONE						
SK-1-3823						
SCALE: 1/4" = 1'-0"		APPROVALS				
DESIGN: HMM	DATE: 2-20-69	BY: J. L. B. (S)	FOR: J. L. B. (S)	DATE: 1-10-69		
CHKD: HMM	DATE: 2-20-69	BY: J. L. B. (S)	FOR: J. L. B. (S)	DATE: 1-10-69		
NO. 10554						
NO. D0-1121						
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC						
PROCESS PIPING REAR FACE GRAVITY FLOW						
REACTOR INCREASED PRODUCTION 105 DR. 8401						
SK-1-3823						

SEE NOTE AT 12-B, THIS DWG.

NO.	DESCRIPTION	REV.	DATE	BY	CHK.
REVISIONS					
NONE					
DRAWN BY: [Signature]					
CHECKED BY: [Signature]					
DATE: 10/1/54					
SCALE: 1/4" = 1'-0"					
PROJECT: 10554					
DRAWING NO: DO-1121					
U. S. ATOMIC ENERGY COMMISSION					
HANFORD ATOMIC PRODUCTS OPERATION					
GENERAL ELECTRIC					
PROCESS PIPING					
REAR FACE GRAVITY FLOW					
REACTOR INCREASED PRODUCTION					
DRAWN BY: 1054 & C					
CHECKED BY: 8401					
DRAWING NO: SK-1-3824					

REF. SK-1-3817, PLAN-REAR FACE PRESS.

DECLASSIFIED

NO.	DESCRIPTION	RECOMMENDED PRESSURE AT NOMINAL FLOW RATE 100°C				RECOMMENDED PIPE SIZES			
		10,000	15,000	20,000	25,000	10,000	15,000	20,000	25,000
1	CONNECTING FITTING	1/2" TUBE	1/2" TUBE	1/2" TUBE	1/2" TUBE	1/2" TUBE	1/2" TUBE	1/2" TUBE	1/2" TUBE
2	CONNECTING OUTLET	1/2" SCH 40	1/2" SCH 40	1/2" SCH 40	1/2" SCH 40	1/2" SCH 40	1/2" SCH 40	1/2" SCH 40	1/2" SCH 40
3	CONNECTING ELBOW	1/2" SCH 40	1/2" TUBE	1/2" TUBE	1/2" TUBE	1/2" SCH 40	1/2" TUBE	1/2" TUBE	1/2" TUBE
4	OUTLET FLANGE	36" NPSM	48" NPSM	48" NPSM	48" NPSM	36" NPSM	48" NPSM	48" NPSM	48" NPSM
5	PIPE SUPPORT	FIXED	ROLLERS TYPE TO ALLOW PIPE TO MOVE	ROLLERS TYPE TO ALLOW PIPE TO MOVE	ROLLERS TYPE TO ALLOW PIPE TO MOVE	FIXED	ROLLERS	ROLLERS	ROLLERS
6	CONNECTING PIPE	NONE	12" SCH 40 E.D. 5-15" AT F. SEE SM-3813 & 14	12" SCH 40 E.D. 5-15" AT F. SEE SM-3813 & 14	12" SCH 40 E.D. 5-15" AT F. SEE SM-3813 & 14	NONE	5-30" SCH 40	5-30" SCH 40	5-30" SCH 40
7	CONNECTING PIPE	36" NPSM	48" NPSM	48" NPSM	48" NPSM	36" NPSM	48" NPSM	48" NPSM	48" NPSM
8	CONNECTING TO DISCHARGE	48" NPSM	72" NPSM	72" NPSM	72" NPSM	54" NPSM	72" NPSM	72" NPSM	72" NPSM
9	PIPE LINE	NONE	48" NPSM	48" NPSM	48" NPSM	NONE	48" NPSM	48" NPSM	48" NPSM
10	DISCHARGE	NONE	NONE	NONE	NONE	54" NPSM	72" NPSM	72" NPSM	72" NPSM
11	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
12	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
13	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
14	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
15	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
16	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
17	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
18	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
19	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000
20	DISCHARGE FROM PIPE	NONE	12,000	14,000	15,000	16,000	18,000	22,000	25,000

REVISIONS	DATE	BY	APP'D	REASON
1	10/15/54	T. Blum		Initial Design
2	11/15/54	T. Blum		Revised Design
3	12/15/54	T. Blum		Final Design

ITEM	DESCRIPTION	QTY.	UNIT	PRICE	TOTAL
1	1" PIPE	100	FT	1.00	100.00
2	2" PIPE	50	FT	2.00	100.00
3	3" PIPE	20	FT	3.00	60.00
4	4" PIPE	10	FT	4.00	40.00
5	6" PIPE	5	FT	6.00	30.00
6	8" PIPE	2	FT	8.00	16.00
7	10" PIPE	1	FT	10.00	10.00
8	12" PIPE	1	FT	12.00	12.00
9	14" PIPE	1	FT	14.00	14.00
10	16" PIPE	1	FT	16.00	16.00
11	18" PIPE	1	FT	18.00	18.00
12	20" PIPE	1	FT	20.00	20.00
13	22" PIPE	1	FT	22.00	22.00
14	24" PIPE	1	FT	24.00	24.00
15	26" PIPE	1	FT	26.00	26.00
16	28" PIPE	1	FT	28.00	28.00
17	30" PIPE	1	FT	30.00	30.00
18	32" PIPE	1	FT	32.00	32.00
19	34" PIPE	1	FT	34.00	34.00
20	36" PIPE	1	FT	36.00	36.00
21	38" PIPE	1	FT	38.00	38.00
22	40" PIPE	1	FT	40.00	40.00
23	42" PIPE	1	FT	42.00	42.00
24	44" PIPE	1	FT	44.00	44.00
25	46" PIPE	1	FT	46.00	46.00
26	48" PIPE	1	FT	48.00	48.00
27	50" PIPE	1	FT	50.00	50.00
28	52" PIPE	1	FT	52.00	52.00
29	54" PIPE	1	FT	54.00	54.00
30	56" PIPE	1	FT	56.00	56.00
31	58" PIPE	1	FT	58.00	58.00
32	60" PIPE	1	FT	60.00	60.00
33	62" PIPE	1	FT	62.00	62.00
34	64" PIPE	1	FT	64.00	64.00
35	66" PIPE	1	FT	66.00	66.00
36	68" PIPE	1	FT	68.00	68.00
37	70" PIPE	1	FT	70.00	70.00
38	72" PIPE	1	FT	72.00	72.00
39	74" PIPE	1	FT	74.00	74.00
40	76" PIPE	1	FT	76.00	76.00
41	78" PIPE	1	FT	78.00	78.00
42	80" PIPE	1	FT	80.00	80.00
43	82" PIPE	1	FT	82.00	82.00
44	84" PIPE	1	FT	84.00	84.00
45	86" PIPE	1	FT	86.00	86.00
46	88" PIPE	1	FT	88.00	88.00
47	90" PIPE	1	FT	90.00	90.00
48	92" PIPE	1	FT	92.00	92.00
49	94" PIPE	1	FT	94.00	94.00
50	96" PIPE	1	FT	96.00	96.00
51	98" PIPE	1	FT	98.00	98.00
52	100" PIPE	1	FT	100.00	100.00
53	102" PIPE	1	FT	102.00	102.00
54	104" PIPE	1	FT	104.00	104.00
55	106" PIPE	1	FT	106.00	106.00
56	108" PIPE	1	FT	108.00	108.00
57	110" PIPE	1	FT	110.00	110.00
58	112" PIPE	1	FT	112.00	112.00
59	114" PIPE	1	FT	114.00	114.00
60	116" PIPE	1	FT	116.00	116.00
61	118" PIPE	1	FT	118.00	118.00
62	120" PIPE	1	FT	120.00	120.00
63	122" PIPE	1	FT	122.00	122.00
64	124" PIPE	1	FT	124.00	124.00
65	126" PIPE	1	FT	126.00	126.00
66	128" PIPE	1	FT	128.00	128.00
67	130" PIPE	1	FT	130.00	130.00
68	132" PIPE	1	FT	132.00	132.00
69	134" PIPE	1	FT	134.00	134.00
70	136" PIPE	1	FT	136.00	136.00
71	138" PIPE	1	FT	138.00	138.00
72	140" PIPE	1	FT	140.00	140.00
73	142" PIPE	1	FT	142.00	142.00
74	144" PIPE	1	FT	144.00	144.00
75	146" PIPE	1	FT	146.00	146.00
76	148" PIPE	1	FT	148.00	148.00
77	150" PIPE	1	FT	150.00	150.00
78	152" PIPE	1	FT	152.00	152.00
79	154" PIPE	1	FT	154.00	154.00
80	156" PIPE	1	FT	156.00	156.00
81	158" PIPE	1	FT	158.00	158.00
82	160" PIPE	1	FT	160.00	160.00
83	162" PIPE	1	FT	162.00	162.00
84	164" PIPE	1	FT	164.00	164.00
85	166" PIPE	1	FT	166.00	166.00
86	168" PIPE	1	FT	168.00	168.00
87	170" PIPE	1	FT	170.00	170.00
88	172" PIPE	1	FT	172.00	172.00
89	174" PIPE	1	FT	174.00	174.00
90	176" PIPE	1	FT	176.00	176.00
91	178" PIPE	1	FT	178.00	178.00
92	180" PIPE	1	FT	180.00	180.00
93	182" PIPE	1	FT	182.00	182.00
94	184" PIPE	1	FT	184.00	184.00
95	186" PIPE	1	FT	186.00	186.00
96	188" PIPE	1	FT	188.00	188.00
97	190" PIPE	1	FT	190.00	190.00
98	192" PIPE	1	FT	192.00	192.00
99	194" PIPE	1	FT	194.00	194.00
100	196" PIPE	1	FT	196.00	196.00
101	198" PIPE	1	FT	198.00	198.00
102	200" PIPE	1	FT	200.00	200.00
103	202" PIPE	1	FT	202.00	202.00
104	204" PIPE	1	FT	204.00	204.00
105	206" PIPE	1	FT	206.00	206.00
106	208" PIPE	1	FT	208.00	208.00
107	210" PIPE	1	FT	210.00	210.00
108	212" PIPE	1	FT	212.00	212.00
109	214" PIPE	1	FT	214.00	214.00
110	216" PIPE	1	FT	216.00	216.00
111	218" PIPE	1	FT	218.00	218.00
112	220" PIPE	1	FT	220.00	220.00
113	222" PIPE	1	FT	222.00	222.00
114	224" PIPE	1	FT	224.00	224.00
115	226" PIPE	1	FT	226.00	226.00
116	228" PIPE	1	FT	228.00	228.00
117	230" PIPE	1	FT	230.00	230.00
118	232" PIPE	1	FT	232.00	232.00
119	234" PIPE	1	FT	234.00	234.00
120	236" PIPE	1	FT	236.00	236.00
121	238" PIPE	1	FT	238.00	238.00
122	240" PIPE	1	FT	240.00	240.00
123	242" PIPE	1	FT	242.00	242.00
124	244" PIPE	1	FT	244.00	244.00
125	246" PIPE	1	FT	246.00	246.00
126	248" PIPE	1	FT	248.00	248.00
127	250" PIPE	1	FT	250.00	250.00
128	252" PIPE	1	FT	252.00	252.00
129	254" PIPE	1	FT	254.00	254.00
130	256" PIPE	1	FT	256.00	256.00
131	258" PIPE	1	FT	258.00	258.00
132	260" PIPE	1	FT	260.00	260.00
133	262" PIPE	1	FT	262.00	262.00
134	264" PIPE	1	FT	264.00	264.00
135	266" PIPE	1	FT	266.00	266.00
136	268" PIPE	1	FT	268.00	268.00
137	270" PIPE	1	FT	270.00	270.00
138	272" PIPE	1	FT	272.00	272.00
139	274" PIPE	1	FT	274.00	274.00
140	276" PIPE	1	FT	276.00	276.00
141	278" PIPE	1	FT	278.00	278.00
142	280" PIPE	1	FT	280.00	280.00
143	282" PIPE	1	FT	282.00	282.00
144	284" PIPE	1	FT	284.00	284.00
145	286" PIPE	1	FT	286.00	286.00
146	288" PIPE	1	FT	288.00	288.00
147	290" PIPE	1	FT	290.00	290.00
148	292" PIPE	1	FT	292.00	292.00
149	294" PIPE	1	FT	294.00	294.00
150	296" PIPE	1	FT	296.00	296.00
151	298" PIPE	1	FT	298.00	298.00
152	300" PIPE	1	FT	300.00	300.00
153	302" PIPE	1	FT	302.00	302.00
154	304" PIPE	1	FT	304.00	304.00
155	306" PIPE	1	FT	306.00	306.00
156	308" PIPE	1	FT	308.00	308.00
157	310" PIPE	1	FT	310.00	310.00
158	312" PIPE	1	FT	312.00	312.00
159	314" PIPE	1	FT	314.00	314.00
160	316" PIPE	1	FT	316.00	316.00
161	318" PIPE	1	FT	318.00	318.00
162	320" PIPE	1	FT	320.00	320.00
163	322" PIPE	1	FT	322.00	322.00
164	324" PIPE	1	FT	324.00	324.00
165	326" PIPE	1	FT	326.00	326.00
166	328" PIPE	1	FT	328.00	328.00
167	330" PIPE	1	FT	330.00	330.00
168	332" PIPE	1	FT	332.00	332.00
169	334" PIPE	1	FT	334.00	334.00
170	336" PIPE	1	FT	336.00	336.00
171	338" PIPE	1	FT	338.00	338.00
172	340" PIPE	1	FT	340.00	340.00
173	342" PIPE	1	FT	342.00	342.00
174	344" PIPE	1	FT	344.00	344.00
175	346" PIPE	1	FT	346.00	346.00
176	348" PIPE	1	FT	348.00	348.00
177	350" PIPE	1	FT	350.00	350.00
178	352" PIPE	1	FT	352.00	352.00
179	354" PIPE	1	FT	354.00	354.00
180	356" PIPE	1	FT	356.00	356.00
181	358" PIPE	1	FT	358.00	358.00
182	360" PIPE	1	FT	360.00	360.00
183	362" PIPE	1	FT	362.00	362.00
184	364" PIPE	1	FT	364.00	364.00
185	366" PIPE	1	FT	366.00	366.00
186	368" PIPE	1	FT	368.00	368.00
187	370" PIPE	1	FT	370.00	370.00
188	372" PIPE	1	FT	372.00	372.00
189	374" PIPE	1	FT	374.00	374.00
190	376" PIPE	1	FT	376.00	376.00
191	378" PIPE	1	FT	378.00	378.00
192	380" PIPE	1	FT	380.00	380.00
193	382" PIPE	1	FT	382.00	382.00
194	384" PIPE	1	FT	384.00	384.00
195	386" PIPE	1	FT	386.00	386.00
196	388" PIPE	1	FT	388.00	388.00
197	390" PIPE	1	FT	390.00	390.00
198	392" PIPE	1	FT	392.00	392.00
199	394" PIPE	1	FT	394.00	394.00
200	396" PIPE	1	FT	396.00	396.00
201	398" PIPE	1	FT	398.00	398.00
202	400" PIPE	1	FT	400.00	400.00
203	402" PIPE	1	FT	402.00	402.00
204	404" PIPE	1	FT	404.00	404.00
205	406" PIPE	1	FT	406.00	406.00
206	408" PIPE	1	FT	408.00	408.00
207	410" PIPE	1	FT	410.00	410.00
208	412" PIPE	1	FT	412.00	412.00
209	414" PIPE	1	FT	414.00	414.00
210	416" PIPE	1	FT	416.00	416.00
211	418

SECT B-B

SECT C-C

NOTE:
SEE DWG. SK-I-3812, SHTS 1 & 2 FOR
DELINERATION OF NEW WORK.

REVISIONS		DATE	BY	APP'D	CHK'D
NONE					
SK-I-3828		1	1	1	1
SCALE: NONE		APPROVAL			
DESIGNED BY: [Signature]		CHECKED BY: [Signature]			
DRAWN BY: [Signature]		INSP. BY: [Signature]			
MATERIAL: MONBY		P.P.M.			
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
PROCESS PIPING FRONT FACE HIGH FLOW ALT.					
REACTOR INCREASED PRODUCTION					
105-B		8401			
SK-I-3828

SECTION B-B

SECTION C-C

SECTION A-A

NOTE:
SEE DWG. SK-I-3812, SHTS 102 FOR
DELINEATION OF NEW WORK.

REVISIONS		REV	DATE
NONE		7	Nov 16 50
SK-I-3829		1	1
SCALE: NONE	APPROVAL	DATE	BY
DESIGNED BY: DATE: 11-16-50	CHECKED BY: DATE: 11-16-50	APPROVED BY: DATE: 11-16-50	BY: 11-16-50
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC			
PROCESS PIPING VALVE PIT ARRGT. HIGH FLOW ALTERNATE			
REACTOR INCREASED PRODUCTION			
105-B	8403		
SK-I-3829		1	1

PLAN-REAR FACE 105 B D & F REACT

SECTION THRU PROCESS HEADER

NOTE:
SEE DWG. 3K-1-3812, SHT. 2 FOR
DELINATION OF NEW WORK.

REVISIONS		REV.	DATE
NONE			
5K-1-3813			
SCALE: 1/4" = 1'-0"		APPROVALS	
DESIGNED BY: [Signature]		DESIGNED	DATE
CHECKED BY: [Signature]		CHECKED	DATE
DRAWN BY: HILLMAN PSM		DRAWN	DATE
NO. 10554			
DO-1121			
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC			
PROCESS PIPING 105 B D&F REAR FACE PRESSURIZATION REACTOR INCREASED PRODUCTION NO. 105 B D&F TAIL 3401 5K-1-3813

NOTE:
SEE DWG. SK-1-3812, SHT. 2 FOR
DELINEATION OF NEW WORK.

REVISIONS		DATE	BY	CHKD	APP'D
NONE					
<div style="display: flex; justify-content: space-between;"> SK-1-3814 11/15/50 </div>					
SCALE: 1/8" = 1'-0"		REVISIONS NO. 1 DATE 11/15/50 BY J. R. HARRIS CHKD J. R. HARRIS APP'D J. R. HARRIS			
PROJECT NO. 10354		U. S. ATOMIC ENERGY COMMISSION			
DRAWING NO. 00-1121		HANFORD ATOMIC PRODUCTS OPERATION			
		GENERAL ELECTRIC			
PROCESS PIPING 105 BD4F					
REAR FACE					
PRESSURIZATION					
REACTOR INCREASED PRODUCTION					
105 BD4F (SHEET 6401)					
SK-1-3814					

REV. 10544	SLV.-OUTLET END PROCESS WATER
REV. 10545	DETAIL PROTAIL GUIDES
REV. 10546	PLAN 105 BD4F REAR FACE PRESSURIZATION
REV. 10547	REAR FACE PRESSURIZATION
REV. 10548	REAR FACE PRESSURIZATION
REV. 10549	REAR FACE PRESSURIZATION
REV. 10550	REAR FACE PRESSURIZATION
REV. 10551	REAR FACE PRESSURIZATION
REV. 10552	REAR FACE PRESSURIZATION
REV. 10553	REAR FACE PRESSURIZATION
REV. 10554	REAR FACE PRESSURIZATION
REV. 10555	REAR FACE PRESSURIZATION
REV. 10556	REAR FACE PRESSURIZATION
REV. 10557	REAR FACE PRESSURIZATION
REV. 10558	REAR FACE PRESSURIZATION
REV. 10559	REAR FACE PRESSURIZATION
REV. 10560	REAR FACE PRESSURIZATION
REV. 10561	REAR FACE PRESSURIZATION
REV. 10562	REAR FACE PRESSURIZATION
REV. 10563	REAR FACE PRESSURIZATION
REV. 10564	REAR FACE PRESSURIZATION
REV. 10565	REAR FACE PRESSURIZATION
REV. 10566	REAR FACE PRESSURIZATION
REV. 10567	REAR FACE PRESSURIZATION
REV. 10568	REAR FACE PRESSURIZATION
REV. 10569	REAR FACE PRESSURIZATION
REV. 10570	REAR FACE PRESSURIZATION
REV. 10571	REAR FACE PRESSURIZATION
REV. 10572	REAR FACE PRESSURIZATION
REV. 10573	REAR FACE PRESSURIZATION
REV. 10574	REAR FACE PRESSURIZATION
REV. 10575	REAR FACE PRESSURIZATION
REV. 10576	REAR FACE PRESSURIZATION
REV. 10577	REAR FACE PRESSURIZATION
REV. 10578	REAR FACE PRESSURIZATION
REV. 10579	REAR FACE PRESSURIZATION
REV. 10580	REAR FACE PRESSURIZATION
REV. 10581	REAR FACE PRESSURIZATION
REV. 10582	REAR FACE PRESSURIZATION
REV. 10583	REAR FACE PRESSURIZATION
REV. 10584	REAR FACE PRESSURIZATION
REV. 10585	REAR FACE PRESSURIZATION
REV. 10586	REAR FACE PRESSURIZATION
REV. 10587	REAR FACE PRESSURIZATION
REV. 10588	REAR FACE PRESSURIZATION
REV. 10589	REAR FACE PRESSURIZATION
REV. 10590	REAR FACE PRESSURIZATION
REV. 10591	REAR FACE PRESSURIZATION
REV. 10592	REAR FACE PRESSURIZATION
REV. 10593	REAR FACE PRESSURIZATION
REV. 10594	REAR FACE PRESSURIZATION
REV. 10595	REAR FACE PRESSURIZATION
REV. 10596	REAR FACE PRESSURIZATION
REV. 10597	REAR FACE PRESSURIZATION
REV. 10598	REAR FACE PRESSURIZATION
REV. 10599	REAR FACE PRESSURIZATION
REV. 10600	REAR FACE PRESSURIZATION

NOTE:
SEE DWG. SK-1-3812, SHT. 2 FOR
DELINERATION OF NEW WORK.

9	W-1746	OVERALL SUPERSTRUCTURE - REAR FACE
8	W-1747	SECTION BY ELEV 55'-6"
7	W-1748	KEY PLAN
6	W-1749	SECTION
5	W-1750	SECTION & DETAILS
4	W-1751	SECTION FLOOR PLAN
3	W-1752	SECTION PLAN BY ELEV 55'-6"
2	W-1753	SECTION SLAB OUTLET END
1	W-1754	SECTION REAR FACE REAR FACE

REVISIONS		DATE	BY	CHKD	DATE
NONE					
SK-1-3815		SCALE: 1/4" = 1'-0" DRAWN: HAD CHECKED: J. L. BROWN DATE: 11/15/59			
10554		DO-1121			
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC &					
PROCESS PIPING REAR FACE PRESSURIZATION					
REACTOR INCREASED PRODUCTION 105 OR 8401					
SK-1-3815

NOTE:
5 DWG. SK-1-3813, SHEET 2
DELINERATION OF NEW WALL.

9	1/4\"/>
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REVISIONS		DATE	BY	APP'D	CHK'D
NONE		2/28/59			
SK-1-3816					
SCALE 1/4" = 1'-0"		APPROVAL			
DRAWN BY: HAHN		CHECKED BY: HAHN			
DATE: 11/2/58		DATE: 11/2/58			
10554					
DO-1121					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
PROCESS PIPING REAR FACE PRESSURIZATION					
REACTOR INCREASED PRODUCTION 10554					
SK-1-3816

NOTE:
SEE DWG. SK-1-3812, JNT 2 FOR
DELINERATION OF NEW WORK.

REVISIONS		REV.	DATE	BY	CHKD.
NONE					
SK-1-3817		~	~	0	
SCALE: 1/8" = 1'-0"		APPROVALS			
DESIGN	DATE	CHKD.	DATE	BY	CHKD.
10554	11/24/59				
DO-1121					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
PROCESS PIPING REAR FACE PRESSURIZATION					
REACTOR INCREASED PRODUCTION					
105 H.R.C.		8401			
SK-1-3817		~ ~ ~			

SK-1-3812-ELEVATION-REAR FACE PRESS.

CLASSIFICATION		SECRET	CONFIDENTIAL	RESTRICTED
CLASSIFICATION		NONE		
3000-200 11/24/59		3000-200 11/24/59		
SK-1-3818		- - - 0		
SERIAL 46's 110° 10554 DO-1121		APPROVAL 11/24/59		
U. S. ATOMIC ENERGY COMMISSION SAFFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC		REAR FACE PRESSURIZATION		
REACTOR HIGH-TEMPERATURE PRODUCTION		10554 EC 280T		
SK-1-3818		- - - 0

PLAN

SECTION A

NOTE:
 EXISTING EFFLUENT LINE 60° FROM
 1\"/>

100 LBS
 AIR COLLECTION
 CHAMBER
 2\"/>

60° EFFLUENT LINES &
 2\"/>

REVISIONS		DATE	BY
NONE		12-31-59	
SK-1-3819			
SCALE: 3/8\"/>		REVISIONS	
DRAWN: MANN		CHECKED: MANN	
DATE: 1-11-60		DATE: 1-11-60	
NO. 10554			
DO-1121			
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC			
PROCESS PIPING DEPRESSURIZATION STATION			
REACTOR INCREASED PRODUCTION			
NO. 10513, D & F.		NO. 8401	
SK-1-3819		SK-1-3819	

REV. NO.	DESCRIPTION
1	ISSUED FOR CONSTRUCTION
2	REVISIONS
3	SK-1-3819

END

**DATE
FILMED**

2 / 9 / 93