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TITLE

IMPROVED COOLANT BACKUP 100-B, D, F, DR, H and C AREAS DESIGN STUDY

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IMPROVED COOLANT BACKUP
100-B, D, F, DR, H, and C AREAS
DESIGN STUDY

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IMPROVED COOLANT BACKUP
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DESIGN STUDY

I. INTRODUCTION

Preliminary engineering studies [1][2][3] have indicated the need for modifications and improvements to the reactor coolant backup systems of the old areas in order to provide adequate safety of operation at power levels programmed for the future. These evaluations of the coolant backup systems were based on the recently adopted reactor cooling safety criteria (See Appendix).[4] It was concluded that the secondary coolant systems would be adequate in capacity and reliability for the proposed future operating conditions except for certain cases of natural disaster such as earthquake damage. It was concluded that the last ditch coolant systems would be inadequate for the proposed future reactor operating conditions.

The purpose of this report is to define the scope of modifications and improvements required to provide adequate last ditch systems in the old areas for future operating conditions as proposed by the Reactor Modification Program, Irradiation Processing Department, Fiscal Years 1961 through 1966.[5] Adequate last ditch cooling will be provided for the 100-K Areas under Project CGI-844 which is currently in progress. The results of this study provide a basis for future budgeting action and project planning.

II. SUMMARY AND CONCLUSIONS

In order to provide an adequate last ditch coolant backup system for the six older reactors, modifications and additions to the existing system will be required. Several cases for study were considered in order to cover the possible future operating conditions and requirements.

These are summarized below:

Case	Operating Condition	Date Required	Estimated Cost
A	Interim Condition	FY-1961	$ 860,000
B-1	Nonexpansion, No Earthquake Protection	FY-1963-64	940,000
B-2	Nonexpansion, Earthquake Protection	FY-1963-64	5,200,000
C-1	Expansion, No Earthquake Protection	FY-1964	4,100,000
C-2	Expansion, Earthquake Protection	FY-1964	5,300,000

In general, the work required under Case A will provide larger initial high tank flows in those areas where existing high tank flow rates are expected to be inadequate in FY-1961. Certain minor changes will be required in the export system to improve reliability and capacity. Cleaning and coating of all high tank interiors will also be needed to improve reliability. An emergency portable raw water pumping system will be needed to assure continuity of cooling in the event of failure of the backup water systems.

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Modifications for Case A would be required for an interim condition and so would be in addition to work required later under one of the other cases.

Case B, the continuity of operation case for FY-1963-64, will require work to increase the initial high tank flow rates in areas where this was not done under Case A. For Case B-1, in which no earthquake protection was considered, additional work to improve the export system reliability will be required. For Case B-2, where earthquake protection was considered, a new independent last ditch pumping system will be needed in each area to replace the export system. Strengthening of 190 tanks, 187 high tanks, and associated piping will be required to insure that both process water during the 190 pump flywheel decay period and high-tank water would be available to the reactor valve pits.

In Case C, the expansion case, the work required includes all of the general items listed under Case B plus an independent last ditch pumping system in each area. For Case C-2, which includes earthquake protection, the modifications to the 190 tanks and to the 187 high tanks and piping listed under Case B-2 will also be required.

For Case C-1, which does not include earthquake protection, consideration was given to installing an additional high tank at each reactor, and improving the export system reliability, instead of installing the independent pumping stations. Either alternate would supply adequate reactor cooling. The estimated cost of the alternates is approximately equal. However, although the export system reliability could be improved considerably, it could never be raised to the degree possible with an independent pumping system. This fact, combined with the lack of any cost advantage, makes the independent pumping system more attractive for both of the expansion cases, C-1 and C-2.

III. DISCUSSION

A. Existing Last Ditch System

The existing last ditch cooling system at the old reactors consists of two 300,000 gallon capacity high tanks at each reactor and the export water system. Upon loss of both the primary (190 Building electrical driven pumps) and the secondary (190 Building steam driven pumps) coolant supplies, the last ditch system supplies coolant flow to the reactor. Under this condition, the process water flow initially decays according to the characteristics of the primary system pump flywheels. At approximately 48 psi top of riser pressure the check valves in the high tank discharge piping open and the tanks supply filtered water to the reactor until they empty in approximately sixty minutes. When the high tanks are nearly empty, raw water is supplied to the reactor from the export system by the automatic opening of a control valve. The configuration of the export system is shown by SK-1-4397, page 28.

B. Design Basis

This section describes the basic design criteria used in the preliminary design described in this report.

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1. Last Ditch System Criteria

The previously evolved "Reactor Cooling System Reliability Safety Criteria"[4] were followed in the design study. These criteria require that the last ditch cooling systems must be independent of both the primary (190 Building electrical driven pumps) and secondary (190 Building steam driven pumps) cooling systems, including piping to the reactor manifolding. It must be capable of providing adequate shutdown flow indefinitely, assuming instantaneous loss of power to the primary system and concurrent failure of the secondary system to provide its rated flow. Adequate shutdown flow is defined, as a minimum, as that required to maintain the bulk outlet temperatures at or below 90°C after the initial temperature transient and to prevent boiling in all process tubes and piping.

2. Capacity Requirements

a. Reactor Operating Conditions

Capacity requirements for the last ditch systems were based on operating conditions resulting from the proposed programs set forth in the Reactor Modification Program, Irradiation Processing Department, Fiscal Years 1961 through 1966.[5] To provide for the proposed future operating conditions, three possible operating cases were considered: an interim case, the continuity of operation and safety case (nonexpansion case) and the expansion case. Reactor operating conditions for the three cases were taken as shown in Table I.

Operating conditions for the interim case (Case A) were assumed to be in effect during the period FY-1961 to about FY-1963-64 at which time either Case B or C conditions would be expected to exist.

b. Reactor Flow Requirements

The coolant flow rates required by the reactor following a power loss were obtained by use of the equation:[3]

$$G_\theta = \frac{f_d \, P \, (1 + f_g)}{.264 \, (t_o - f_t - t_i)} \qquad \text{where:}$$

f_d = Heat generation decay factor for θ minutes after a scram.[3]

f_g = Low flow scale up factor for flow error.[2]

t_o = Bulk outlet water temperature, °C.

f_t = Bulk temperature scale up factor for low flow conditions.[2]

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TABLE I

REACTOR OPERATING CONDITIONS

Case		Effective Date, FY	Reactor Flow, GPM	Bulk Outlet Temp., °C	Power Level MW, t_i=20°C	TORP PSI	No. of Proc. Pumps	PUMP TDH, PSI
Interim (Case A)	100B,D,F,DR,H	1961	85,000	95	1680	545	7	580
	100-C	1961	95,000	95	1880	395	9	445
Nonexpansion (Case B)	100-B,D,F,DR,H	1963	90,000	95	1780	525	7	560
	100-C	1962	100,000	95	1980	375	9	427
Expansion (Case C)	100-B,D,F,DR,H	1964	115,000	95	2280	405	7	455
	100-C	1964	115,000	95	2280	345	10	407

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t_1 = Inlet water temperature, °C.

G_θ = Required flow to the reactor θ minutes after a power loss in 1000 gpm.

P = Reactor operating power level before the scram in MW.

The maximum allowable bulk outlet temperature was taken as 90°C.

The temperature of the inlet water supplied from the high tanks and the export system was taken as 27°C. It was assumed that high tanks would be adequately cooled to maintain this temperature or below. Measurements indicate a maximum water temperature of 27°C for the export system.(2)

The required flow rates are shown plotted vs.time after power loss for the three cases on Figure 1 and 2 in the appendix.

The results of heat generation decay tests planned for the future may require revision of calculated flow requirements and perhaps revision of the recommended coolant backup modifications.

c. <u>Required High Tank Flow Rates</u>

The required high tank flow rates were obtained from the intersection of the flywheel flow decay curves and the reactor required flow curves. The flywheel flow decay curves were calculated from the following equation:(2)

$$\frac{G_\theta}{G_o} = \left(\frac{1}{1+\alpha\theta}\right)^{1.15}$$

G_θ = Available reactor flow θ minutes after a scram, gpm

G_o = Initial total reactor flow before scram, gpm

θ = Time after scrams, seconds

α = Flywheel decay constant = $\frac{29.2\ TDH_o\ G_o\ g}{e\ I_o\ n^2\ N_p}$

TDH = Pump total dynamic head before power loss, psi

e = Pump and drive efficiency

I_o = Pump and flywheel moment of inertia - lbs. ft^2

n = Initial flywheel speed - rpm

N_p = Number of pumps operating in parallel

The flywheel decay curves and their intersection with the reactor-required flow curves are shown for the three cases by Figures 1

 [redacted]

and 2 in the Appendix. The resulting required high tank flow rates, rounded off to the nearest 500 gpm, are also tabulated below:

Case	Required High Tank Flow Rate, GPM 100-B, D, DR, F, H	100-C
A	12,500	13,000
B	13,500	14,000
C	17,500	16,000

d. Required Export Line Flow Rates

An estimate of the required export system flow rates was obtained from Figures 1 and 2 by determining the approximate time in which the existing high tanks would empty when delivering flow at the required rate. The resulting values were used as a design guide. More exact values for the required export system flow rates depend on the depletion time of the high tanks which can be adjusted by details of design and operation. For example, the duration of the high tank flow depends upon the characteristics of the tank discharge piping, the reactor system characteristic and the time which the export system starts to supply water. Closer estimates for the required export system flow rates were determined in connection with specific proposed modifications which are discussed in a following section.

3. Reliability Requirements

In addition to adequate flow capacity the last ditch system must have a high degree of reliability. Items which were considered to have a significant effect on system reliability are listed and discussed as follows:(1)(3)

a. Disasters

The effects of earthquake, windstorm, ice storm, floods, low water level, river stoppage and evaluation were considered. The effects of a severe earthquake had considerable influence on the extent of the modifications. For this reason, the study cases were further subdivided to include additional cases for earthquake protection as follows:

Case	Earthquake Protection
A	No
B-1	No
B-2	Yes
C-1	No
C-2	Yes

Design requirements for earthquake resistance were based on results of studies recently performed by Holmes and Narver, Inc.

[redacted]

of Los Angeles[1] and a proposed HAPO earthquake resistance criteria[7]. In this study modifications for earthquake protection were considered for the last ditch cooling systems only. These modifications would be but a portion of an overall earthquake protection program for the complete reactor plants.

The portable raw water pumping systems proposed for Case A would provide a degree of coolant backup protection in the event of flood, low river level, or even river stoppage.

No specific proposals are included for improvement of coolant backup reliability in the event of evacuation. However, the independent last ditch pumping facility proposed for Cases B-2, C-1, and C-2 would also provide increased reliability during an evacuation.

Windstorm and ice storm were discussed in an earlier study.[1] They will not be considered further as no modifications to existing systems are felt to be required for protection from these storms.

Damage resulting from enemy action, sabotage, or failure of Grand Coulee Dam has not been considered in making the recommendations included in this report. Previous studies[9] have indicated that construction of coolant backup systems to provide some resistance to bomb blast or to a Grand Coulee flood would cost over $14,000,000. This cost figure was based on an underground pumping station near each reactor capable of supplying the reactor through either the front or rear face piping. Since the front face piping integrity is doubtful in the event of such a catastrophe the pumping station would automatically supply the reactor through the better protected rear face piping if a significant part of the front piping were destroyed. If such a system were installed, the less expensive earthquake protection measures included in this report would not be required.

b. <u>High Tanks and Piping Corrosion</u>

Corrosion has caused considerable accumulation of rust in the existing high tanks and discharge piping. The rust accumulation could cause plugging of high tank strainers. Continued rusting may produce penetration of the tank and piping walls. The accumulation of corrosion products in the high tank discharge piping has caused appreciable flow reduction as evidenced by results of recent cleaning of this piping. High tank flow rates were increased 25 to 35 percent in 100-B, D, and F Areas by chemical cleaning of the discharge piping. The resulting flow rates were in close agreement with the calculated values for clean piping. Based on these findings, the values used for the existing high tank flow rates were those determined by calculations for clean pipes. These values are shown by Figures 3, 4, 5, and 6 and are listed in Table II.

TABLE II
EXISTING HIGH TANK FLOW RATES CALCULATED FOR CLEANED PIPING

Area	High Tank Flow, GPM
B, D, F	10,000
DR	13,500
H	12,600
C	13,700

This study assumes the chemical cleaning of all high tank discharge piping will be accomplished by plant maintenance programs. Cleaning has been completed in B, D, F, and H Areas and is expected to be accomplished at DR and C Areas prior to completion of modifications proposed for Case A(Interim). Periodic cleaning will be required at infrequent intervals in the future as determined by test or inspection.

c. Excessive Water Temperature

The effectiveness of the last ditch system depends on water temperature in addition to flow capability. High tank water temperatures vary with weather conditions and have been observed to be as high as 37°C during the summer months.(2) Water temperatures up to 27°C have been measured in the export system.(2) A design temperature of 27°C was assumed for the last ditch water supply. Cooling of the high tank water was considered a design requirement and will be accomplished by continuous flushing of colder filtered water through the high tanks.

d. Export System Pumping

The present export system pumping capacity is adequate for the following "worst" condition of emergency: that is, when there is a total electric power failure to all 100 Areas and a concurrent steam plant failure in one dual reactor area. During this condition, three steam driven pumps supply the export line, however, if any of these pumps fail to start within the required time the last ditch system flow rates would be reduced below the minimum required. For the case of steam plant failures in more than one area (a credible situation in case of earthquake damage) it was considered necessary to provide an independent pumping station in each area to supply last ditch cooling in place of the export system. Installation of spare pumping capacity and the automatic starting of steam driven pumps was considered a necessary design requirement to provide adequate pumping reliability for the existing export system.

e. Surge Suppressors

Two Pelton surge suppressors are located at each of the 182 Building pumping stations which supply the export system. The surge

[redacted]

suppressors open to bypass water to the 182 Building reservoir during a flow transient in order to prevent water hammer damage to the export system piping. The opening of these surge suppressors during the time the export system is furnishing last ditch cooling water could reduce this supply below the minimum required. This problem is being studied by an outside consultant. At this time it appears that the surge suppressors should not be replaced because there are times when they must function to prevent piping damage. It is planned to reduce unnecessary surge suppressor actuation by replacing the control solenoid on each suppressor with a hydraulic diaphragm device. Thus the surge suppressor low trip would be actuated only by low pressure following pump failure rather than by electrical power failure.

To insure proper surge suppressor operation, it may be necessary to add accumulators to supply operating pressure for each suppressor. Installation of slow-closing air admission valves at certain export piping locations may also be required for additional water hammer protection. However, further tests are required before the need for these measures can be definitely established.

f. <u>200 Area Reservoir Valves</u>

The normal function of the export system is to supply water to the 200 Area reservoirs. Control of flow to the reservoirs is by manual setting of the 282 Building cone valves. If these valves happen to be open wide at the time of an emergency considerable export flow may continue to the 200 Areas rather than be diverted to last ditch cooling of a reactor. Control of flow to a definite minimum amount at the 200 Area reservoir was considered a necessary design requirement.

g. <u>Last Ditch System Piping</u>

The complex and interconnected export system lacks the degree of reliability felt to be required. The length of lines beyond that required solely for service to the reactor plants increases the chance for failure. In addition, a single failure in the system could cut off or reduce last ditch coolant flows to any of the areas. Leaks have occurred in the cast iron piping connecting the export system to the 105 Buildings under present operating conditions. It was considered necessary that the cast iron piping in these locations be replaced with steel or that clamps be added to the bell and spigot joints. A currently planned investigation by the Chemical Processing Department should provide further information as to the condition and reliability of export system piping. Any deficiencies which are found would require correction.

For the earthquake protection cases it was considered necessary to use steel in place of cast iron for all last ditch piping, valves, and fittings, and to strengthen piping supports. Clearance holes were also provided at all last ditch piping penetrations through structure walls.

C. <u>Description of Modifications</u>

The modifications required for the reactor last ditch coolant systems are listed below for each case. The work listed under Case A (Interim

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Case) will be required in FY-1961 and is independent of any decision on the proposed earthquake protection and expansion programs. The work listed under one of the remaining cases will be required at a later date in addition to the work included in Case A.

1. <u>Case A - Interim Case</u>

Modifications required to provide an adequate last ditch coolant backup system during the interim period prior to the major modifications planned for FY-1963-64 are listed below:

a. Additional high tank discharge lines B, D and F Areas. Twelve inch diameter piping will be required. A typical arrangement for 105-D is shown on SK-1-4396, page 27. Initial flow expected from the modified high tanks is 14,000 gpm.

b. Stepwise reduction of high tank discharge flow to conserve high tank water supply at areas where additional discharge lines are installed. This will be accomplished by interconnecting the existing 12 inch fill and discharge lines inside the riser, and cutting off the fill line about 11 feet below the normal water level. This step will decrease the high tank flow to about 11,000 gpm, neglecting export system effects.

c. Extension of the raw water control valve sensing lines inside the high tanks in areas where modifications (a) and (b) are made. The control valve will be opened to admit export water to the reactor about ten minutes after the initial emergency occurs. Although the total reactor coolant flow will be increased, the high tank flow will be decreased and the duration of the high tank supply extended. The high tank discharge flow will be reduced about 20 percent by using the export system in this way, while the total reactor flow is increased about 20 percent.

d. Chemical cleaning of existing high tank discharge piping. This measure will increase the flow through this piping substantially and will permit the use of smaller diameter piping for the additional lines to be installed in modification (a). This cleaning has been completed at B, D, F, and H Areas under a plant maintenance program. It is expected that this work will also be accomplished at C and DR.

e. Installation of temperature recording instrumentation and a suitably orificed drain at each high tank. This will permit control of the high tank water temperature by flushing during hot weather. The maximum flushing flow required for each tank has been estimated to be 75 gpm[8] and is almost certain not to exceed 200 gpm.

f. Automatic starting of the export system steam driven pumps. These pumps must now be manually started and most of them are in normally unmanned buildings. Automatic starting will be required so that export water will be available to a reactor within about ten minutes after power failure.

g. Installation of slightly larger export line orifices at areas where additional high tank discharge lines are installed. Because of earlier depletion of high tank supply at these areas, slightly higher export system flow will be required. An export system flow of 6500 gpm will be adequate in these cases if modifications (b) and (c) are made for maximum conservation of high tank water.

h. Automatic limitation of 200 Area export flow. During an emergency, when only steam pumps will be available on export system, it will be necessary to reduce the 200 Area export flow to the minimum requirement in order to adequately supply a dual reactor area. This will be accomplished by automatically closing the 200 Area cone valves. The minimum emergency flows of about 2700 gpm to 200-E and 850 gpm to 200-W will be supplied through an orificed bypass line.

i. Improvement of export system hydraulic transient protection. Mr. George R. Rich of Charles T. Main, Inc., has been engaged as a consultant to study this problem. His final recommendations have not been made as yet, but it appears that significant gains in export system reliability can be made by improving surge protection and at the same time eliminating some possibilities for unnecessary surge suppressor actuation.

At this time replacement of the electric control solenoid on each surge suppressor with a hydraulic diaphragm device seems desirable. This modification would eliminate surge suppressor actuation by an electric power failure which did not affect the export system pumps. Accumulators to supply operating pressure for the surge suppressors and slow closing air valves at selected points on the export system are also being considered. However, more tests are required to determine whether these are needed.

j. Clean and coat high tank interiors. The tanks are badly corroded, and cleaning and coating will be required to protect the tanks and to reduce the possibility of screen plugging by corrosion products.

k. Portable raw water pumps. Portable pump systems are required to provide emergency reactor cooling if all other sources are lost, or to provide a temporary replacement for the export system to allow maintenance during reactor operation. The pumps could be used to pump from the river to the area reservoirs, from the reservoirs to the reactors, or both. A typical arrangement for 100-B Area is shown on SK-1-4388, page 24. The pumps would be trailer mounted and diesel driven. Connecting piping would be

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invasion type installed on the ground surface and utilizing quick connection couplings. The system proposed could be used in the K Areas as well as the older areas. A typical emergency requiring the portable pump system would be an unusually high or low river level which prevented the use of the 181 river pump houses. Because of the flexibility of such a system it would be useful in many widely different circumstances.

2. Case B-1 - Nonexpansion Case, No Earthquake Protection

The following coolant backup improvements will be required in FY-1963-64 if the expansion program is not implemented and if earthquake protection is not to be provided:

a. Two additional steam driven export system pumps. Under present conditions three steam driven pumps would be available to supply a dual reactor area. Failure of one pump would make the supply inadequate, which condition violates the reactor cooling system safety criteria. Installation of another steam driven pump in both 182-F and 182-H would provide sufficient capacity so that failure of one pump would not jeopardize the reactor last ditch coolant supply.

b. Additional high tank discharge lines at H, C, and DR Areas. FY-1963-64 operating conditions will require modifications at H, C, and DR similar to those required at the other reactors under Case A. A new additional eight inch diameter discharge line will be required for each high tank. At C and DR there is a possibility that new strainers in parallel with the existing strainers may give sufficient flow without a need for additional piping.

c. Replacement of cast iron export system piping with steel piping. The cast iron bell and spigot piping connecting the export system with 105-D, DR, F, and H has generally demonstrated poor reliability. A series of leaks in this piping at 100-B Area resulted in its replacement with steel pipe, which has been more satisfactory. The number of leaks experienced in other areas is high enough to seriously reflect on the reliability of the cast iron pipe in this service. Clamping of the bell and spigot joints of the cast iron pipe is also under consideration as an alternate to complete replacement.

3. Case B-2 - Nonexpansion, Earthquake Protection

In the event that the expansion program is not completed, but earthquake protection is provided, the following coolant backup modifications will be required in FY-1963-64:

a. New independent pumping systems for each area to replace the export system as a reactor last ditch supply. By eliminating

[redacted]

the existing steam driven pumps at the 181 river pump houses and relocating some electrical pumps, new gas turbine or diesel driven pumps will be installed in the 181 Buildings. Piping will be run from the new pumps directly to the reactor piping. A typical arrangement for 100-B Area is shown on drawings SK-1-4389 and SK-1-439C, pages 25 and 26. The system would supply 8000 gpm per reactor. Each pump will be rated at 8000 gpm, 250 Ft. TDH, so that one spare pump would be available in each area.

b. Strengthen high tank structures to provide seismic resistance. Strengthening of columns, replacement of diagonals and spider rods, enlargement of footings, and additional anchor bolts will be required at B, D, and F with less extensive work at other areas.

c. Additional high tank discharge lines at H, C, and DR as in Case B-1.

d. Replace cast iron valves and strainers in existing high tank piping. Improve piping supports and anchors and provide clearance at wall penetrations. This measure will be required to provide seismic resistance.

e. Brace 190 tank foundations at B, D, F, and H Areas and minor bracing of the 190-to-reactor piping in all areas. The tank bracing will be required to prevent shifting of the tanks and rupturing of the 190 pump suction lines in the event of earthquake. Such damage would stop the reactor coolant flow during the critical flywheel decay period immediately following a power failure. The flow available from the high tanks would be inadequate at this time. The 190-to-reactor piping must be kept intact since parts of it form essential sections of both the secondary and last ditch system.

4. <u>Case C-1 - Expansion, No Earthquake Protection</u>

If the proposed expansion program proceeds, but earthquake protection is not provided, the following last ditch coolant backup improvements will be required in FY-1964:

a. Independent last ditch pumping station in each area as in Case B-2. The pump station will be designed to supply 12,000 gpm per reactor as shown on SK-1-4389 and SK-1-4390, pages 25 and 26. Each area will be supplied with one 12,000 gpm, 250 Ft. TDH pump for each reactor and in addition one spare pump.

b. Additional high tank discharge lines at H, C, and DR Reactors as in Case B-1.

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5. Case C-2 - Expansion, Earthquake Protection Provided

If both the expansion program and the earthquake protection program proceed, the following coolant backup improvements will be required in FY-1964:

a. Independent last ditch pumping stations as in Case C-1.

b. Strengthen high tank structure as in Case B-2.

c. Additional high tank discharge lines at H, C, and DR Reactors as in Case B-1.

d. Replace cast iron valves and strainers in existing high tank piping. Improve piping supports and anchors and provide clearance at wall penetrations, as in Case B-2.

e. Brace 190 tank foundations at B, D, F, and H Areas and 190-to-reactor piping in all areas as in Case B-2.

APPENDIX A

BIBLIOGRAPHY

1. HW-64996 "Interim Report, Coolant Backup Study", W. J. Tupper, August 1, 1960.

2. HW-62861 "Adequacy of the Old Reactor Backup Cooling Systems", S. S. Jones, December 1, 1959.

3. HW-64417 "Review of the Status of Hanford Reactor Emergency Cooling", S. S. Jones, June 1, 1960.

4. HW-59696 "K Water Plant Improvement", R. E. Trumble, et al., March 19, 1959.

5. HW-62862 "Plant Improvement Program, Irradiation Processing Department", A. B. Greninger, April 1, 1960.

6. HW-66334 RD "Preliminary Design Basis, Modifications for Improved Coolant Backup 100-B, D, F, H, DR, and C Areas" M. H. Schack, W. J. Tupper, August 12, 1960.

7. HW-65931 "Seismic Resistance Criteria", O. E. Adams, Jr., W. D. Gilbert, July 8, 1960.

8. HW-66153 "Preliminary Examination of Old Reactor High Tank Flushing Requirements" A. Russel, July 25, 1960.

9. HW-55380 "Supplementary Cooling Systems for Existing Reactors", G. J. Rogers, March 18, 1958.

[redacted]

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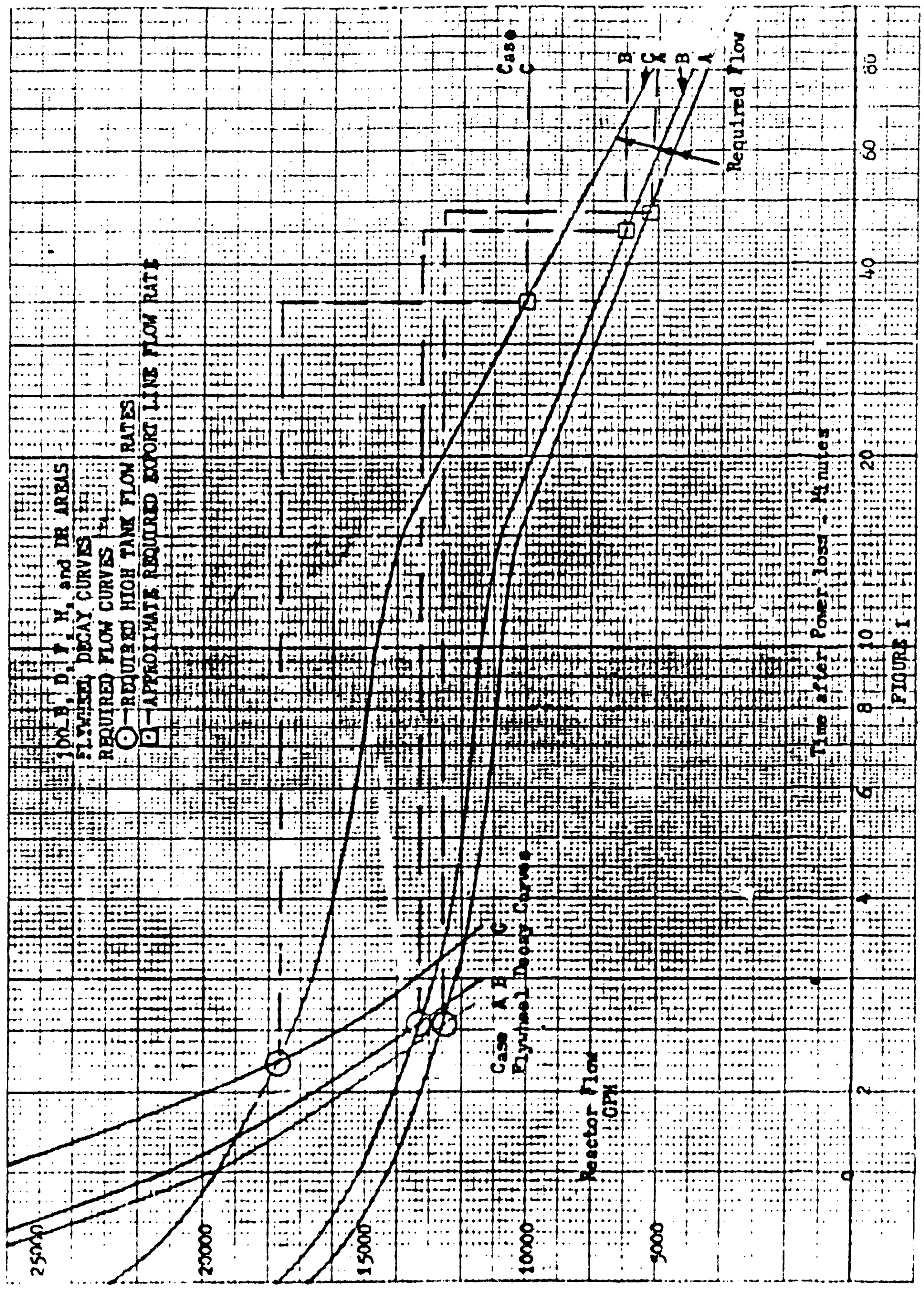
100-B, D, F, H, and DR AREAS
FLYWHEEL DECAY CURVES
REQUIRED FLOW CURVES
REQUIRED HIGH TANK FLOW RATES
APPROXIMATE REQUIRED EXPORT LINE FLOW RATE
Case C
Required Flow
Case A B C
Flywheel Decay Curves
Reactor Flow GPM
25000
20000
15000
10000
5000
Time after Power loss - Minutes
0
2
4
6
8
10
20
40
60
80

FIGURE 1

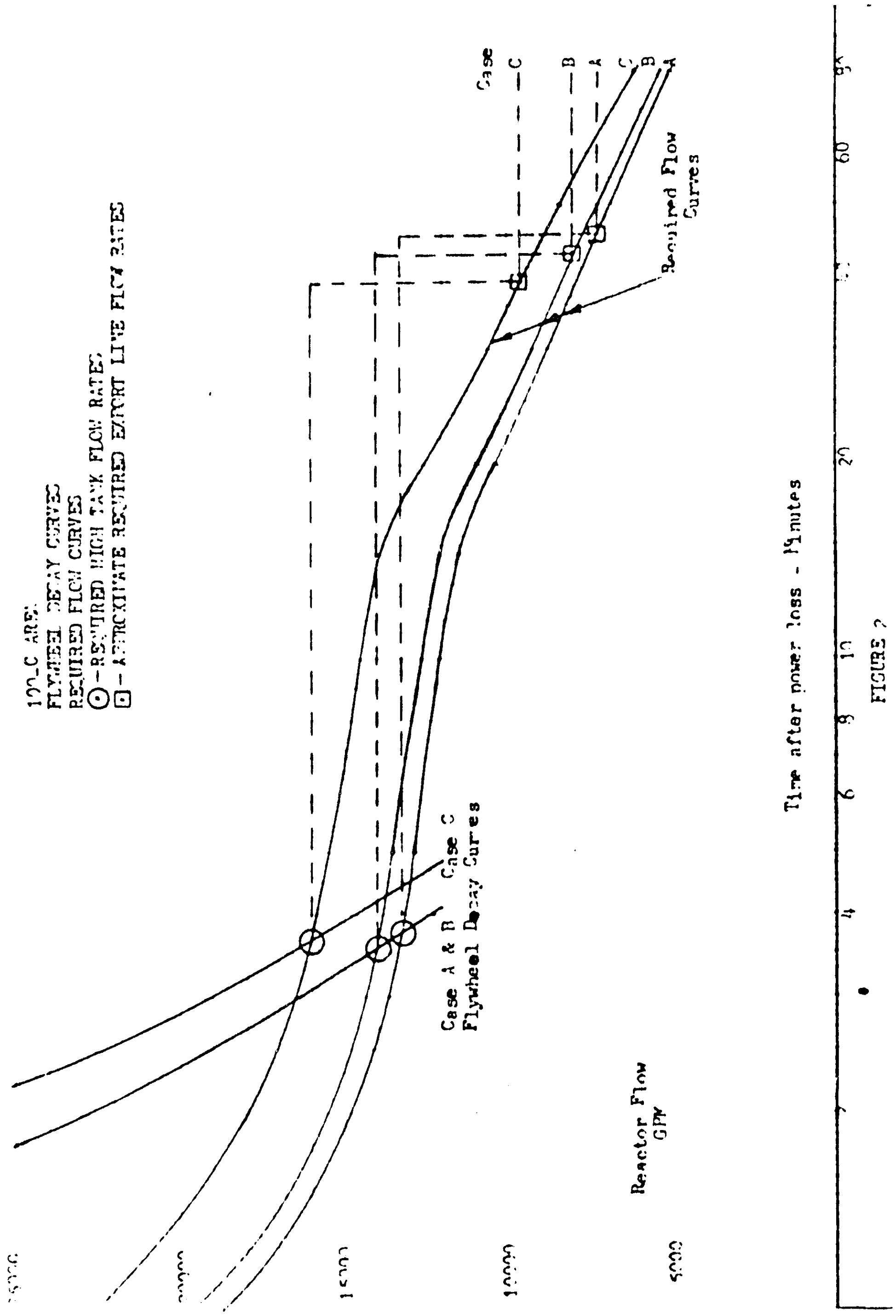

FIGURE 2

[redacted]

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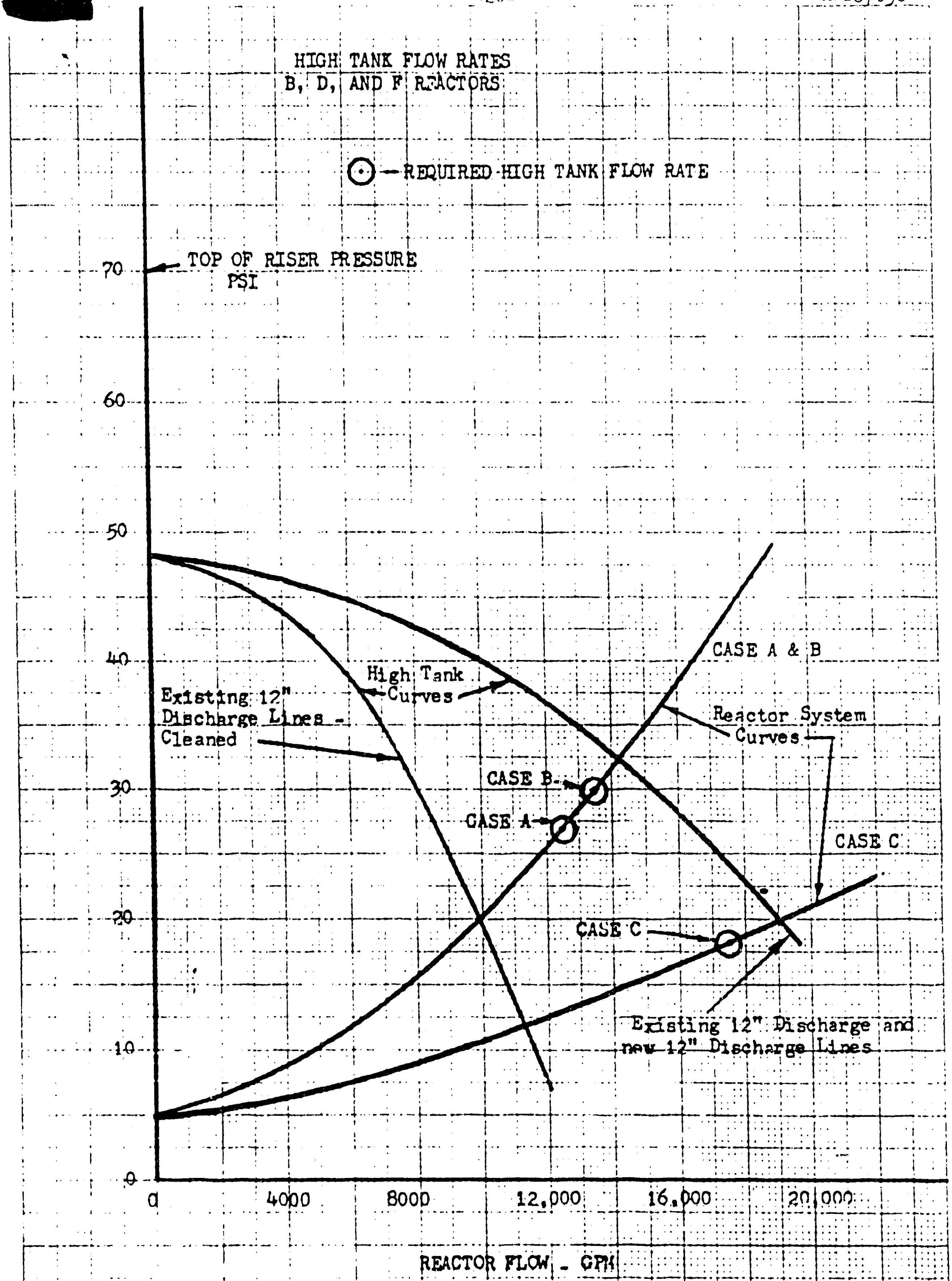

FIGURE 3

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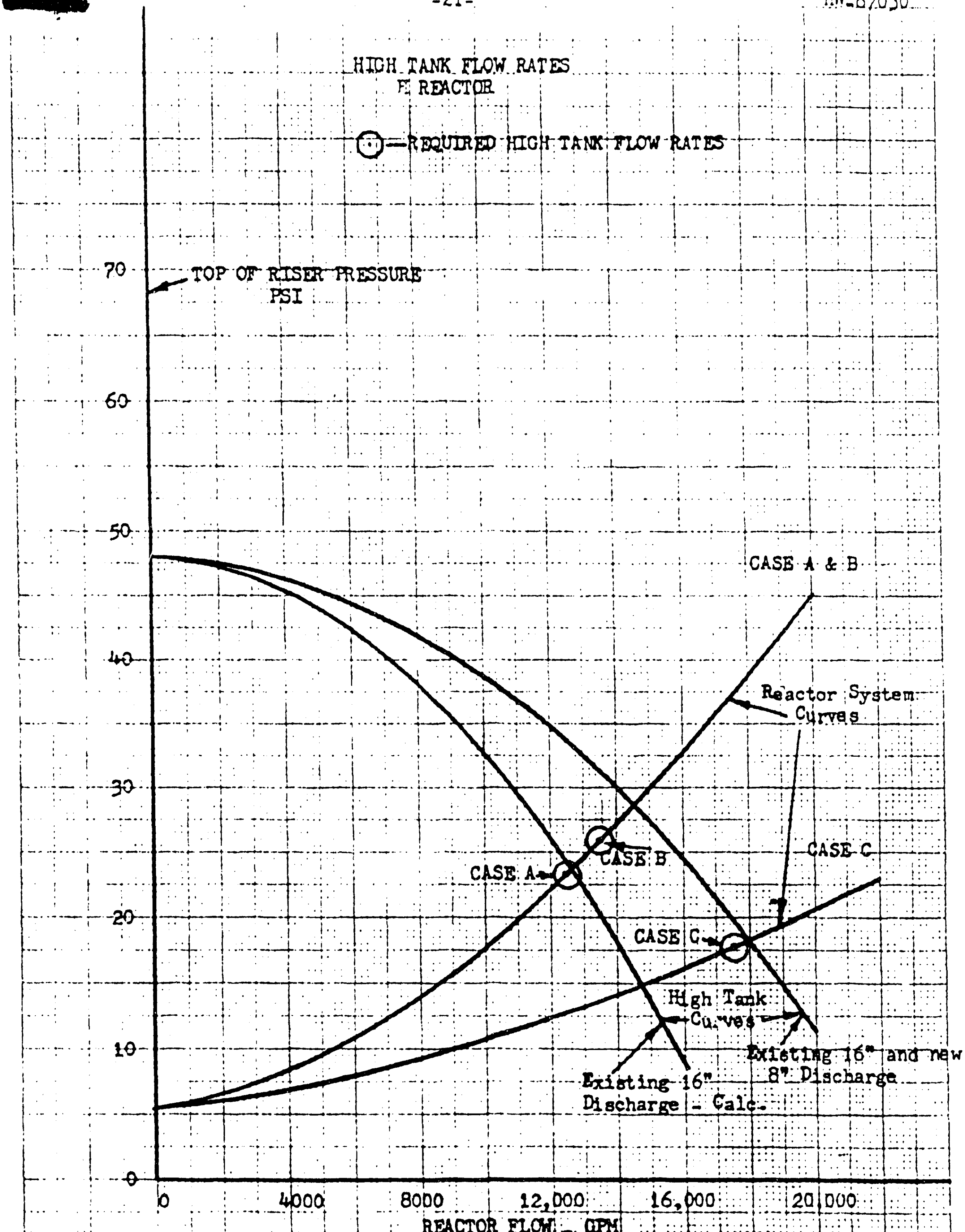

HIGH TANK FLOW RATES
F REACTOR
—REQUIRED HIGH TANK FLOW RATES
TOP OF RISER PRESSURE
PSI
70
60
50
40
30
20
10
0
CASE A & B
Reactor System
Curves
CASE B
CASE A
CASE C
CASE C
High Tank
Curves
Existing 16" and new
8" Discharge
Existing 16"
Discharge - Calc.
0
4000
8000
12,000
16,000
20,000
REACTOR FLOW - GPM

FIGURE 4

[redacted]

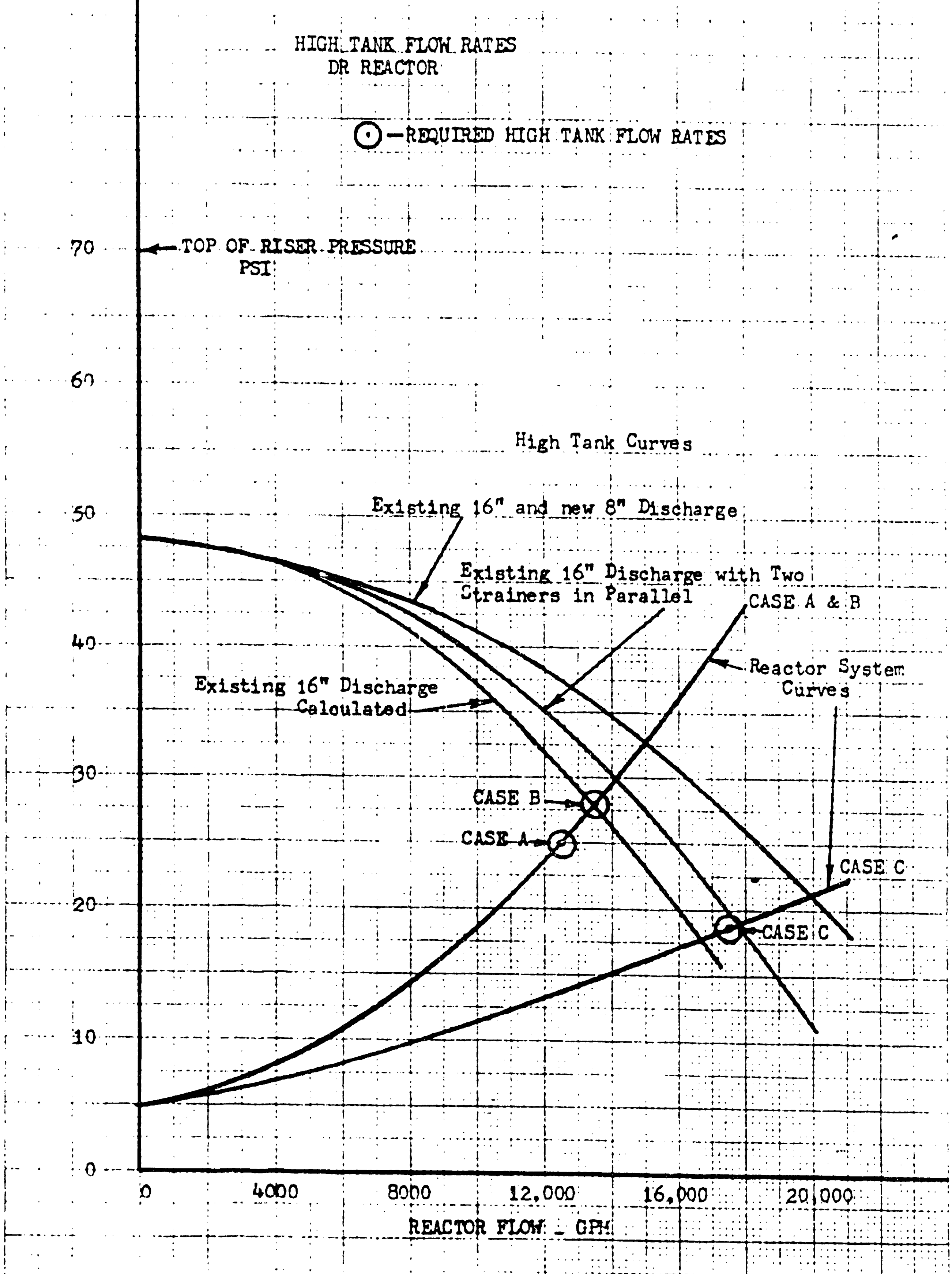


FIGURE 5

[redacted]

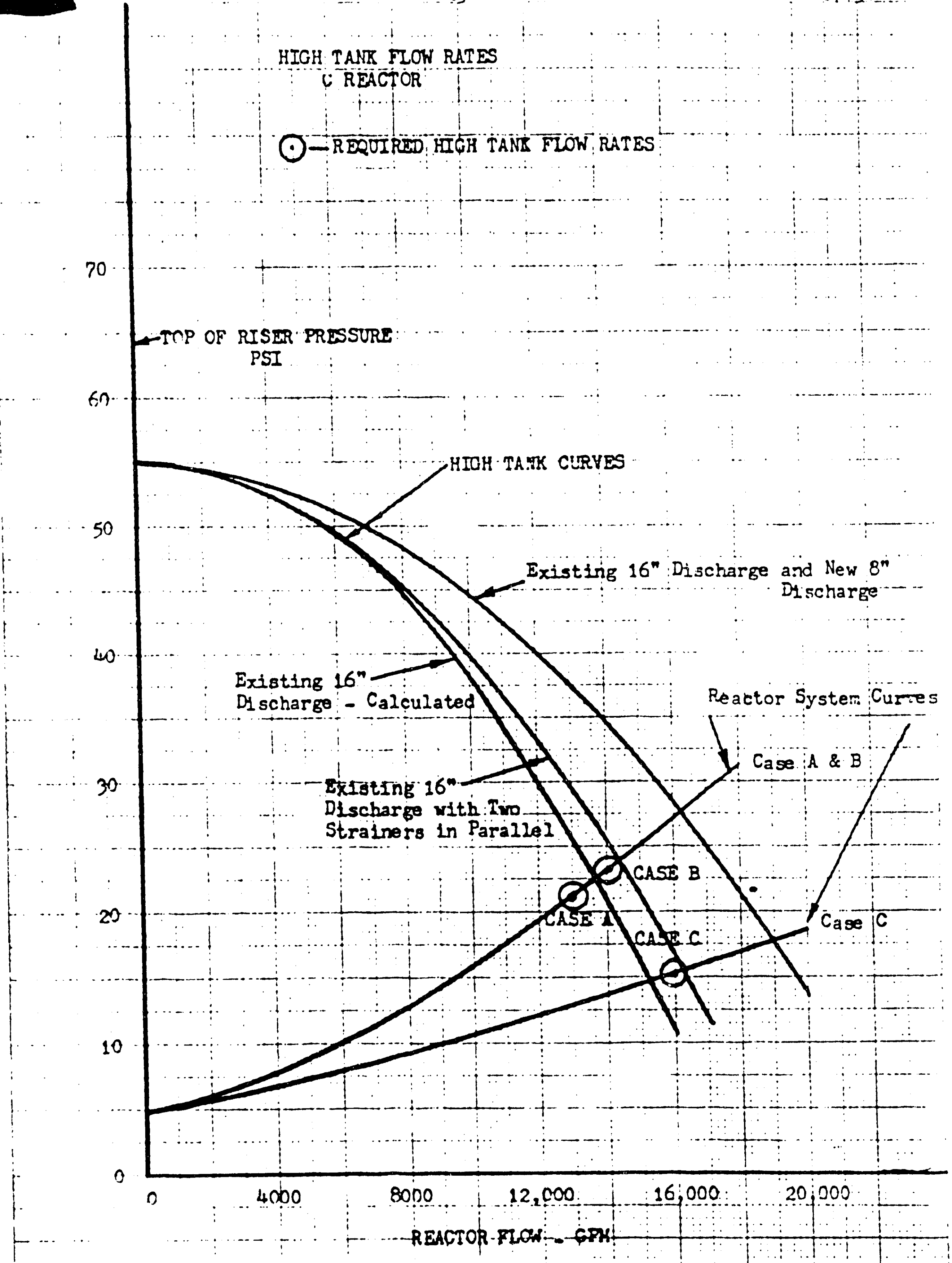
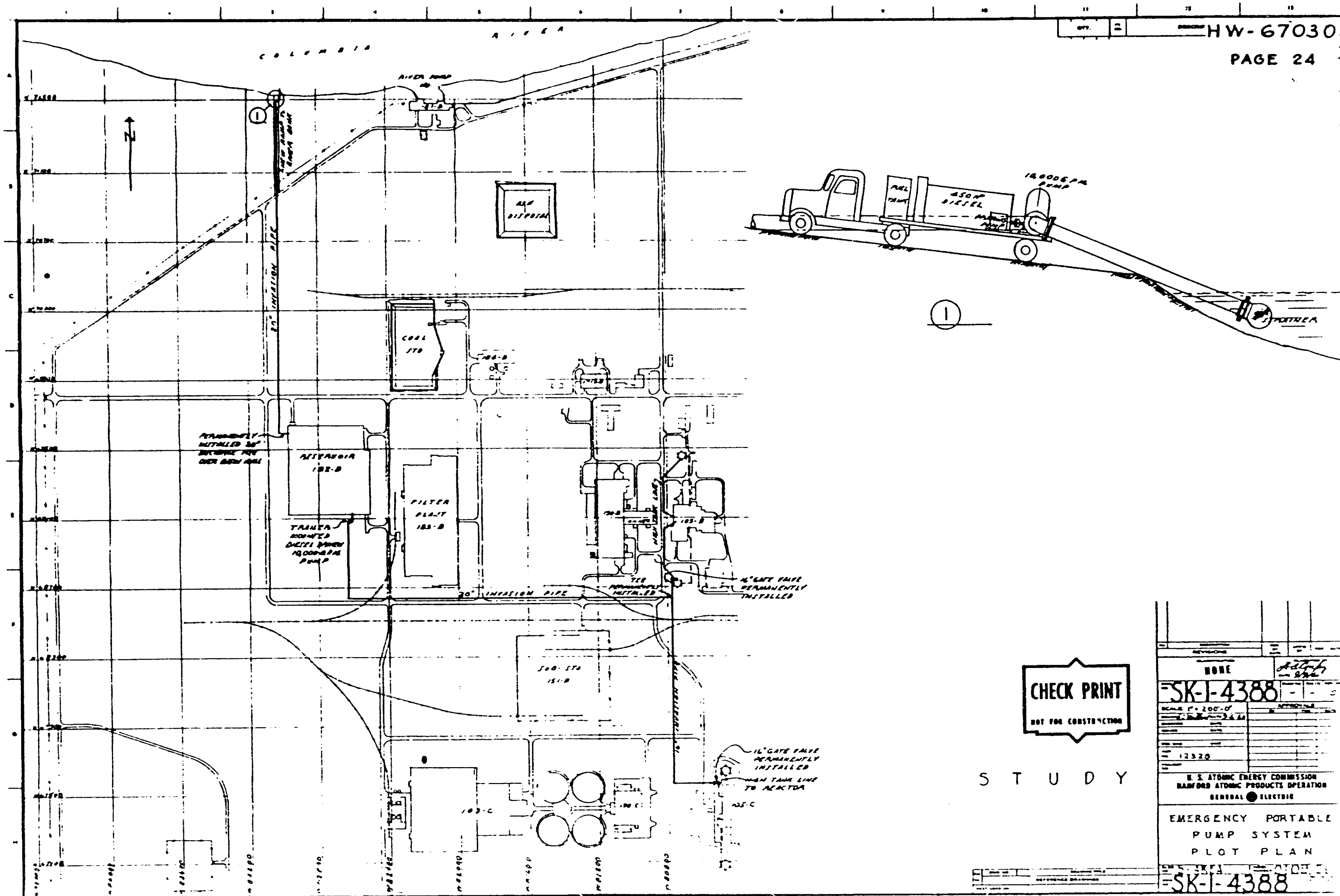
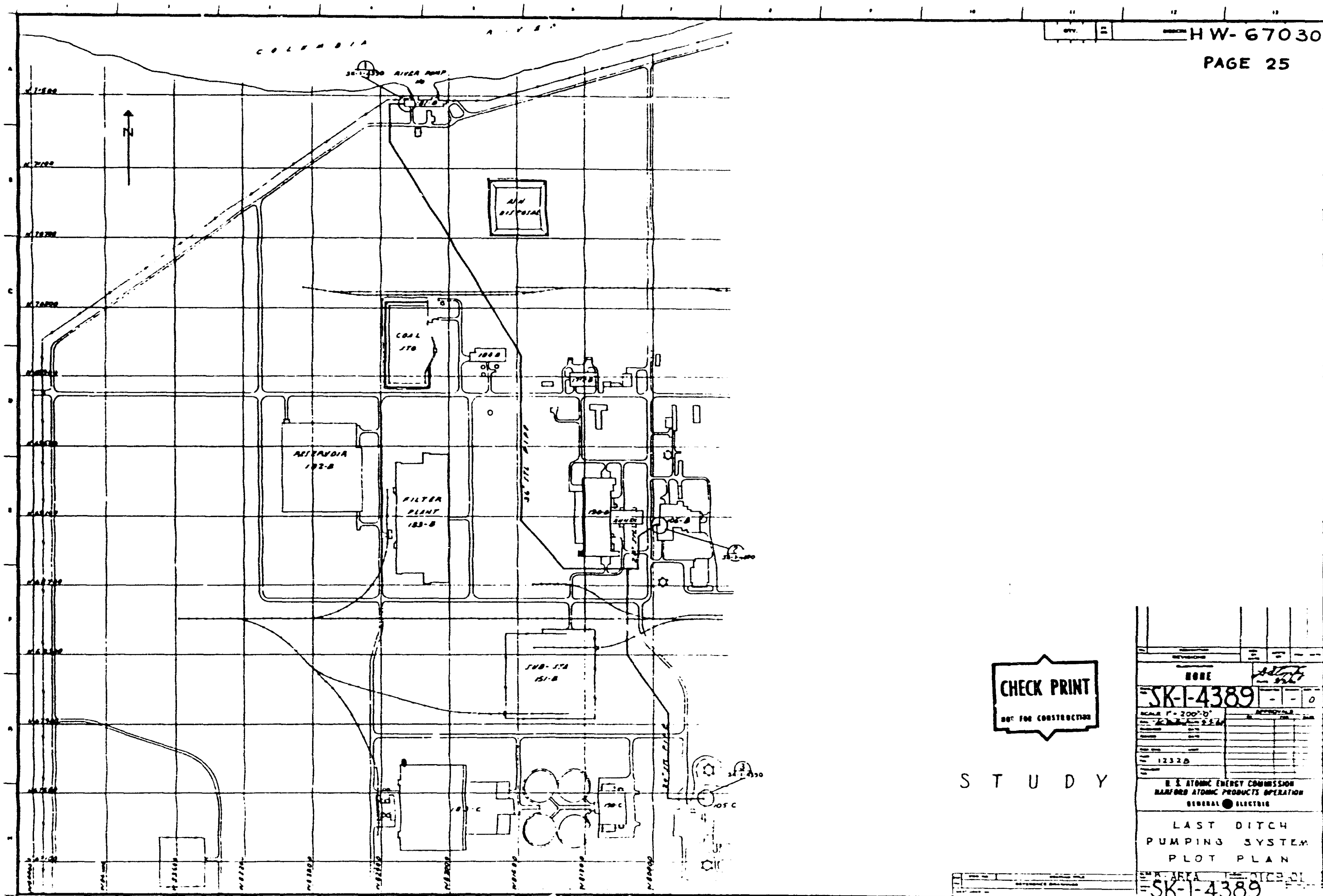
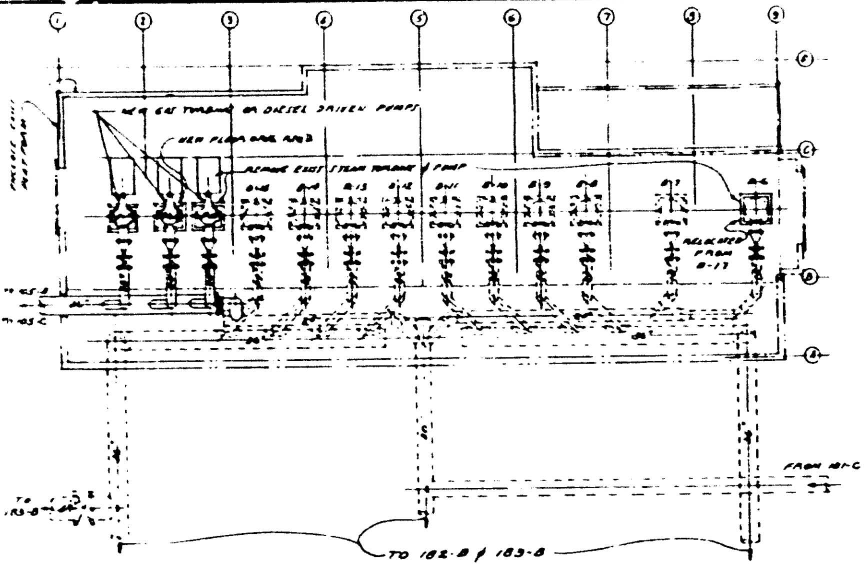

HIGH TANK FLOW RATES
C REACTOR
REQUIRED HIGH TANK FLOW RATES
TOP OF RISER PRESSURE PSI
70
60
50
40
30
20
10
0
HIGH TANK CURVES
Existing 16" Discharge and New 8" Discharge
Existing 16" Discharge - Calculated
Reactor System Curves
Case A & B
Existing 16" Discharge with Two Strainers in Parallel
CASE B
CASE A
CASE C
Case C
0
4000
8000
12,000
16,000
20,000
REACTOR FLOW - GPM

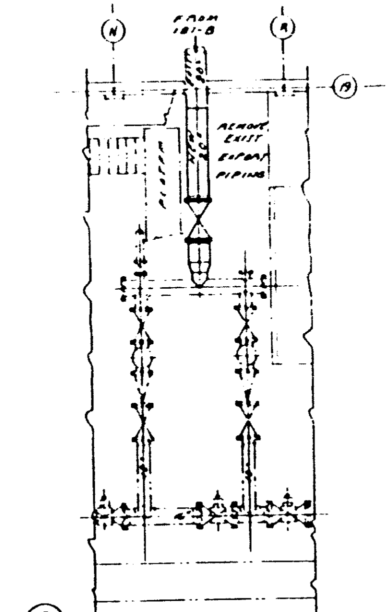
FIGURE 6


COLUMBIA RIVER
RIVER PUMP HO
COAL STG
RESERVOIR 182-B
FILTER PLANT 183-B
SUB-STA 151-B
183-C
20" INVASION PIPE
12'GATE VALVE PERMANENTLY INSTALLED
FUEL TANK
450HP DIESEL
14000GPM PUMP
STRAINER
CHECK PRINT
NOT FOR CONSTRUCTION
S T U D Y
NONE
SK-1-4388
SCALE 1" = 200'-0"
12320
U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC
EMERGENCY PORTABLE
PUMP SYSTEM
PLOT PLAN
SK-1-4388

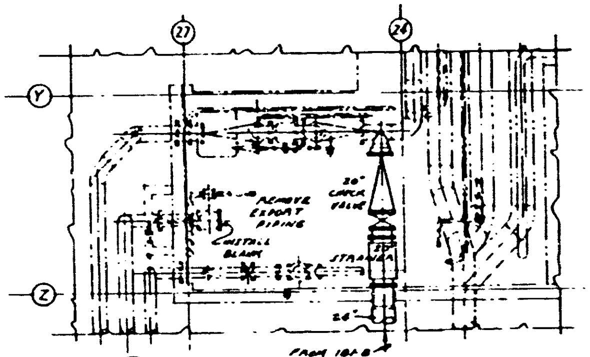

COLUMBIA RIVER
RIVER PUMP
N
ASH DISPOSAL
COAL STG
190-B
RESERVOIR 182-B
FILTER PLANT 183-B
36" FIL PIPE
SUB-STA 151-B
105 C
CHECK PRINT
NOT FOR CONSTRUCTION
STUDY
NONE
SK-1-4389
SCALE 1" = 200'-0"
12328
U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC
LAST DITCH
PUMPING SYSTEM
PLOT PLAN
SK-1-4389



1 PLAN 181-B



2 PLAN-VALVE PIT-105-B



3 PLAN-TUNNEL 105-C

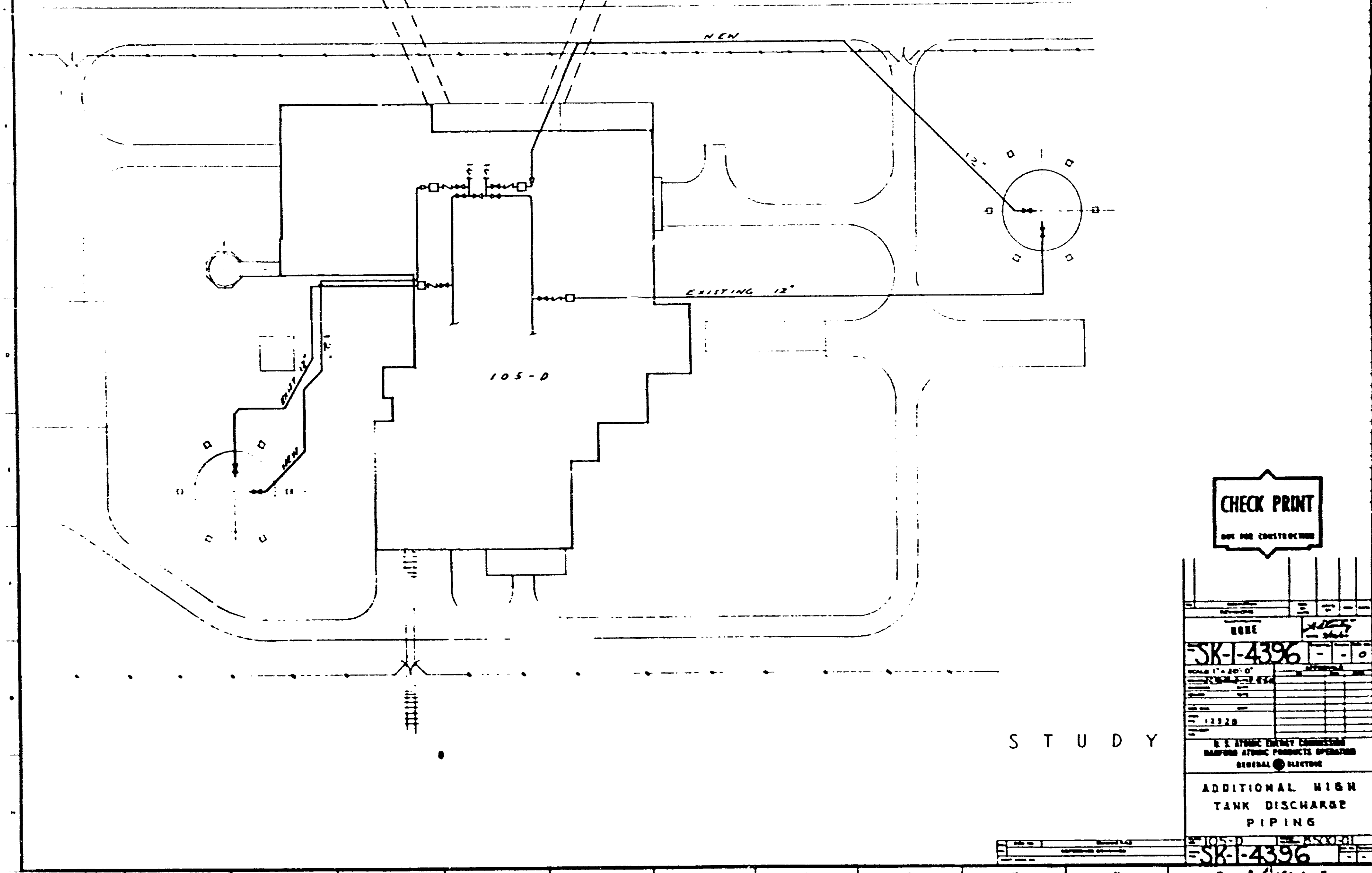
CHECK PRINT
NOT FOR CONSTRUCTION

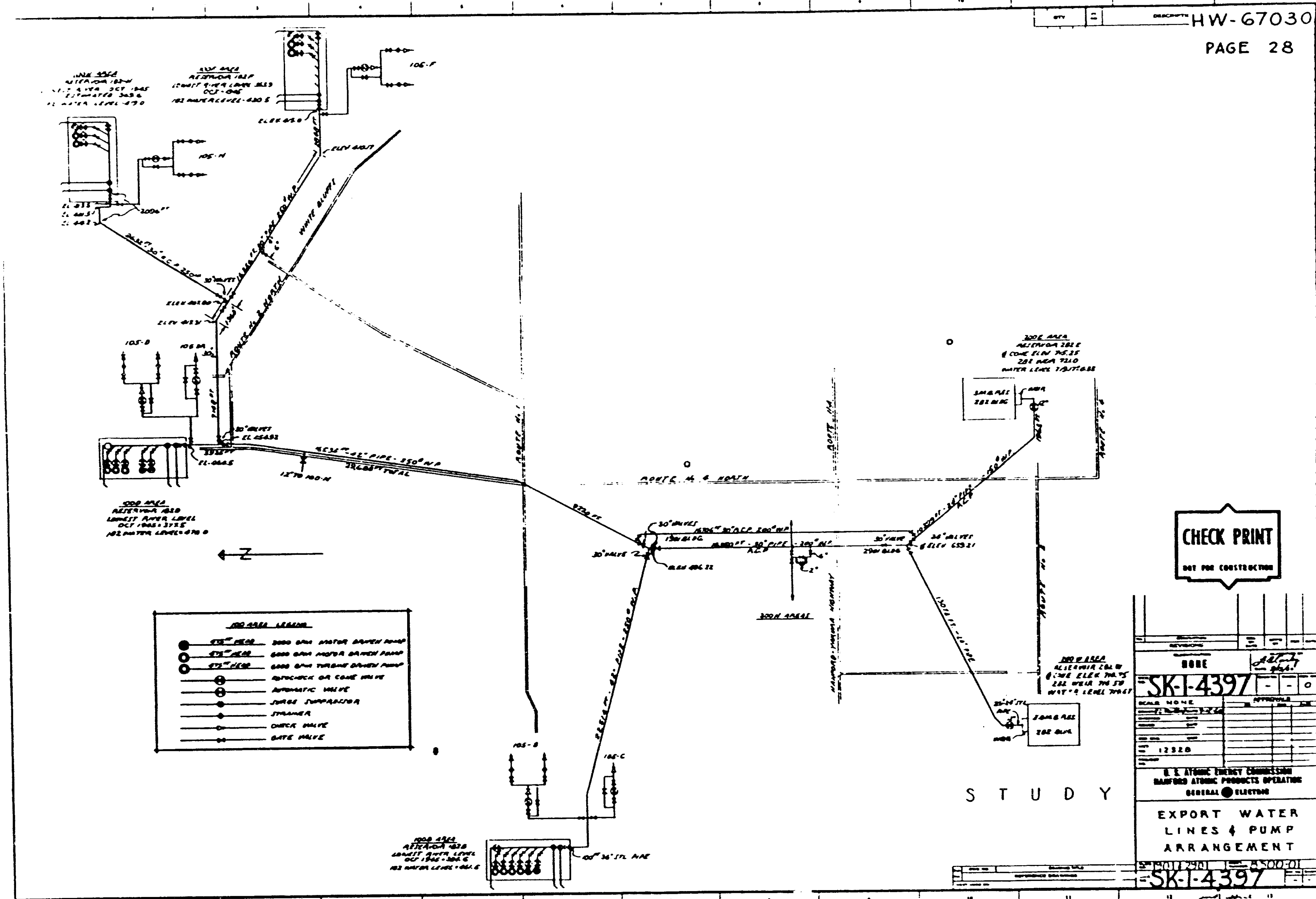
STUDY

NONE
SK-1-4390
12320
U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC

LAST DITCH
PUMPING SYSTEM
PIPING

B AREA 5500-01
SK-1-4390


NEW
12"
EXISTING 12"
105-D
EXIST 12"
12"
NEW
CHECK PRINT
NOT FOR CONSTRUCTION
NONE
SK-1-4396
SCALE 1" = 20'-0"
12320
U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC
ADDITIONAL HIGH
TANK DISCHARGE
PIPING
105-D
SK-1-4396
STUDY


105-F
105-H
105-B
105-C
WHITE BLUFFS
ROUTE 4 S NORTH
ROUTE 4
HANFORD-YAKIMA HIGHWAY
300H AREAS
100 AREA LEGEND
CHECK PRINT
NOT FOR CONSTRUCTION
STUDY
NONE
SK-1-4397
U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC
EXPORT WATER
LINES & PUMP
ARRANGEMENT
SK-1-4397

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APPENDIX D

PRELIMINARY COST ESTIMATE - COOLANT BACKUP STUDIES

FEATURE	CASE A Interim Non-Earthquake	CASE B-1 Non-Expansion Non-Earthquake	CASE B-2 Non-Expansion W/Earthquake	CASE C-1* Expansion Non-Earthquake	CASE C-2 Expansion W/Earthquake
Addi. High Tank Disc. Lines	190,000	165,000	165,000	165,000	165,000
Cooling High Tank Water	45,000				
Auto. Start Stm. Pump	7,000				
200 Area Valve Control	5,000				
Hyd. Surge Sup. & Valves	35,000				
Add'l Steam Pump 182 Bldg.		150,000			
Clean & Coat High Tank Interior	50,000				
Portable River Pumps	320,000				
Replace C.I. Export Line		325,000			
New Pumping Station			2,550,000	2,600,000	2,600,000
Brace High Tank Structures			230,000		230,000
Piping Modifications (High Tanks)			50,000		50,000
190 Bldg. TK Bracing			575,000		575,000
Total Direct Cost	$652,000	$640,000	$3,570,000	$2,765,000	$3,620,000
Const. Engineering	22,000	24,000	105,000	85,000	115,000
Contingency	88,000	155,000	875,000	710,000	880,000
General Overhead	28,000	27,000	150,000	133,000	160,000
Management Services	24,000	27,000	128,000	116,000	140,000
Design	46,000	67,000	372,000	291,000	385,000
TOTAL COST	$860,000	$940,000	$5,200,000	$4,100,000	$5,300,000

*Total cost for Case C-1 with export improvement work from Case B-1 and new high tanks in place of new pumping station - $4,165,000.

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APPENDIX E

REACTOR COOLING SYSTEM RELIABILITY SAFETY CRITERIA

The criteria define normal reactor cooling system requirements as follows:

A. Three independent, reliable sources of cooling:

1. Primary Cooling System

   The primary cooling system will provide adequate reactor cooling during all phases of operation and shutdown. The design and operation shall be such that the secondary or last ditch backup systems are not called upon to provide the sole source of cooling during any phase of normal operation and would not be expected to be required to function as the sole supply system during the life of the plant.

2. Secondary Cooling System

   The secondary cooling system shall be independent of the primary system (common piping is acceptable) and capable of providing adequate shutdown cooling indefinitely assuming instantaneous loss of power to the primary system. Serious consideration should be given the operation of the secondary system at partial flow capability at all times and preferably at a flow capability sufficient to satisfy the full requirements in event of primary system failure without relying upon actuation or acceleration of equipment. That flow provided by the secondary system during normal operation may contribute to the primary cooling system requirements.

3. Last Ditch System

   The last ditch cooling system must be independent of both the primary and secondary cooling systems, including piping to the reactor manifolding. It must be capable of providing shutdown flow indefinitely assuming instantaneous loss of power to the primary system and concurrent failure of the secondary system to provide its rated flow.

B. An independent system is defined as one with power sources and pumping systems such that failures or cause of failure in one cannot induce failure of the alternate systems.

C. Adequate cooling is defined, as a minimum, as that required to maintain reactor components, including fuel elements, at temperatures below the melting point. In practice, the objectives of requiring levels of cooling capable of protecting against all reactor or fuel element damage will be prudent to adopt.

D. Failure of any single component in a system shall not be capable of rendering the system inadequate. In practice certain piping and valves may be qualified as exceptions.

E. All engineering, construction, operation, and maintenance shall meet or exceed requirements specified by applicable codes and standards.

It is recognized that criteria cannot be inflexible in practice and considered evaluation of specialized situations may support responsible authorization of specific exceptions to the stipulated general requirements.

END

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