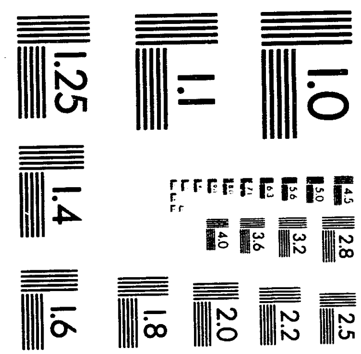

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RLD CG-4, 12-7-93
By Jessie Malley 1-5-94
Verified By J E Savely 1-5-94

September 8, 1958

G. L. Locke
Reactor Design Analysis Operation
IRRADIATION PROCESSING DEPARTMENT

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NPR DESIGN BASIS

INTRODUCTION

The design basis is composed of requirements and conditions for the design of the reactor plant (composed of the reactor and heat dissipation system). Its intent is to insure that the final product meets the economic, safety, and technical objectives of the project.

The design basis is dependent on the ground rules, objectives, technical criteria, and practical design considerations. This document is being issued with the understanding that these items are not yet firmly established in all respects, and therefore, the numbers put down here are subject to change.

Consideration of the spectrum of probable changes that might be made leads to the conclusion that the numbers here are close to the final ones and are satisfactory as a basis for the initial stages of design. Some numbers are omitted because of insufficient data at this time.

GROUND RULES AND OBJECTIVES

Ground Rules

1. Initial operation: 4000/0[(1)]

2. Initial cost: $\$145 \times 10^6$

3. Second phase operation: 4000/300

4. Ability of reactor to accommodate and demonstrate operation of power reactor fuel elements.

(1) 4000 MW is the ultimate operating goal. Its attainment will depend on development work, particularly in the fuel element field. There is no certainty that the reactor can be operated at 4000 MW with the start-up fuel element.

5. Length of time operated at 4000/0: 3 years

6. Length of time operated at 4000/300: 7 years

7. Disposition of plant upon completion of 4000/300 operation: Sell as a power producer to a power company such as a PUD which will operate it for 15 years.

8. Financing scheme:

   A. Government financing for the first 10 years.

   B. PUD type financing for the remaining 15 years with an effective 2-1/2 percent interest charged on the total capital investment for 15 years and 8.3 percent tax on gross power output.

<u>Objectives</u>

1. Minimum cost of conversion between initial and final operation within the above ground rules.

2. Minimum plutonium cost during the first 10 years of operation.(2)

TECHNICAL CRITERIA

The technical criteria is composed of (1) information regarding the properties of materials and the limitations of material under reactor plant operating conditions (i.e., in-reactor creep strength of Zr-2); and (2) methods of predicting physical phenomena where no known method has been satisfactorily developed (i.e., calculation of flux distribution within the reactor). Wherever applicable, the data in reference 1 has been used as the technical criteria.

---

(2) Under some circumstances, objectives 1 and 2 are conflicting. The decision as to which one will take precedent over the other will be deferred until more is known about how conflicting they are.

1.0 Design Basis

1.01 Operating Conditions

		Phase I	Phase II	Phase III
1-Power level	MW	4000	4000	2400
2-Approx. Net Elec. Power Generation	MW	0	300	700
3-Primary Loop Water Temp.	°F			
a-Bulk Outlet		540	540	573
b-Inlet		380	380	505
c-MPT Outlet		556	556	580
4-Flow Rate	lb.hr.	74.5×10^6	74.5×10^6	96.3×10^6
5-Pressures	psig			
a-Front riser		1500 ± 50	1500 ± 50	1645 ± 50
b-Rear riser		1425 ± 50	1425 ± 50	1525 ± 50
6-Orificing Efficiency	%	90	90	90
7-Flattening Efficiency	%	75	75	75

1.02 Fuel Element - Initial Load

1-Type*		7-element cluster	
2-Material		Enriched U Metal, Zr-2 clad	
3-Fuel Diameter	in.	.664	
4-Clad Thickness	in.	.020	
		@ 4000 MW	@ 2400 MW
5-Maximum U Temperature	°F	1170	
6-Bulk Average U Temp.	°F		
7-Design Exposure	MWD/T	2000	2000
8-Pile Load	T	332.1	332.1
9-Enrichment			
a-Initial		0.823	0.832
b-Final		0.606	0.615 [redacted]

*As per Ref. 2, this limits power level to about 3500 MW.

10-Production	Kg/T	@ 4000 MW 1.44	@ 2400 MW 1.45

1.03	**Process Tube**		
	1-Material		Zr-2
	2-Inside Diameter	in.	2.70
	3-Wall Thickness	in.	0.25
	4-Maximum Temperature	°F	675-825
	5-Average Temp. of MPT	°F	
	6-Bulk Average Temp.	°F	
	7-Total Number		1004
	8-Energy Generation	% (5)	0.5
1.04	**Moderator**		
	1-Material		Graphite
	2-Purity, Reflector AGOTCR Equiv. - GBF or Equiv.		
	3-Density of Material	gm/cc	$1.65 \begin{smallmatrix} + .03 \\ - .02 \end{smallmatrix}$
	4-Effective Moderator Density	gm/cc	1.29
	5-Dimensions Over-all (Nominal)	ft-in.	
	a-Length		38'-7-1/2"
	b-Width		33'-2"
	c-Height		30'-3"
	6-Reflector Thickness	in. (3)(4)	
	a-Front and Rear		21-1/2
	b-Sides		49-1/2
	c-Top and Bottom		49-1/2

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7-Temperature	°F	
a-Maximum hot spot		2050-2300
b-Ave. Temp. of Max. Temp. Cell (4" x 9" x 16")		1600-1650
c-Temp. seen by Control Rod		1100-1200
d-Flux Squared Ave. Stack Temp.		
8-Energy Generation	% of total[5]	5
9-No. of Lattice Units		
a-Total[6]		1004
b-In Horizontal Direction		34
c-In Vertical Direction		32
d-Missing from Each Corner		21
10-Lattice Spacing	in.[6]	
a-In Horizontal Direction*		8
b-In Vertical Direction		9

1.05 Primary Shielding[12]		Front & Rear	Sides & Top	Bottom
1-Material				
a-Thermal		CI	Boron Steel	Borated Mortar
b-Biological		Cement-iron concrete	Hydrous-iron concrete	Concrete
2-Thickness				
a-Thermal	in.	8	1	4
b-Biological	in.	40		
3-Energy Generation				
a-Thermal[7]	Btu/ft^2-hr	915	1230	1230
b-Biological				

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* The original 7-inch spacing has been increased to allow steam escape passages in the moderator in the event of a tube rupture.

[redacted]

	Front & Rear	Sides & Top	Bottom
4-Maximum Temperatures			
a-Thermal			
b-Biological			
5-Average Temperatures			
a-Thermal			
b-Biological			

1.06 Horizontal Control & Safety System

1-Type	Rods Entering From Two Sides
2-Control Material	LiAl, 10% nat.Li and B_4C
3-Effective Rod Diameter	(2.55" x .25" thick) and (2.288 LiAl Solid) Dia. of Boron
4-Rod Spacing	27" x 40" maximum
5-Rod Number	76
6-Maximum Rod Temperature	
7-Maximum Energy Gen. in Rod	
8-Active Rod Length	26 ft.
9-Insertion Time Capabilities	1.6 sec. Full, 1.4 sec, 3/4 way
10-Rod Strength	5.9 percent Δk

1.07 Vertical Safety System

1-Type	Ball
2-Material	Stainless Steel, 1-1/2% Boron
3-Channel Diameter	4 in. diameter
4-Number of Channels	68
5-Spacing	32" x 40" max.
6-Drop Time	~ 1-1/2 sec. for first balls to hit bottom
7-Ball Strength	6.2% Δk

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1.08 Primary Coolant

1-Design Pressure (8)	1825 psig or 900 fitting capabilities (whichever is lowest)
2-Normal Water Activity	See Reference 10
3-Maximum Operating Activity	See Reference 10
4-Reactor Pressure Drop Flow Characteristics	Figure 1 attached
5-Heat Transfer to Coolant During Scram	Figure 2 attached
6-Water Quality Requirements	See Reference 11

1.09 Pile Atmosphere

1-Type of Gas	Helium	
2-Flow Rates, cfm	400	
3-Temperature, °F (11)	4000 MW	2400 MW
a-Inlet	80	80
b-Outlet	800	771

1.10 Major Instrumentation Requirements

1-Allowable inlet coolant water temperature variation in steady state operation - °F.	+ 5 -10
2-Allowable flow variation during steady oper.-%	- 5
3-Allowable tube power level variation during steady operation - %	+10
4-Allowable pile power level variation during steady operation - %	+ 2
5-Process tube instrumentation requirements	Flow rate Outlet temp. Outlet activity
6-Bulk inlet water instrumentation	Flow rate Temperature
7-System pressure - %	± 2

[redacted]

8-Nuclear	
a-Range, $n/cm^2/sec.$	$10^2 - 10^{13}$
b-Accuracy - %	
(1) Start-up	± 20
(2) Operating	± 5
c-Response	
(1) Period trips	2 periods
(2) Start-up level trip	1-2 sec.
(3) Operating trip	1/4 sec.
d-Trips Required	
(1) Start-up range	Period & Level
(2) Approach to upper range	Rate & Level
(3) Operating range	Level
9-Moderator	
a-Temperature	
(1) Range, °C	10-1200
(2) Time response, min.	1
(3) Accuracy, °C	± 10
b-Atmosphere	
(1) Thermal Conductivity	
Range -	
Accuracy - %	± 10
Time response - min.	1
(2) O_2 and H_2O Concentration	
Range - %	0-2.5
Accuracy - %	± 10
Time response, min.	1

[redacted]

REFERENCES

(1) HW-53612, "Technical Criteria and Bases, Pressurized Water-Cooled, Graphite Moderated Production Reactor", R. L. Dickeman, Confidential-Undocumented.

(2) HW-56634, "NPR Power Level Limitations Imposed by Uranium Core Temperatures", D. L. Condotta, June 26, 1958.

(3) HW-55658, "NPR Reflector Thicknesses, D. E. Wood, April 9, 1958.

(4) HW-56482, "The Effects of Temperature and Flattening on the NPR Reflector Thicknesses," D. E. Wood, June 26, 1958.

(5) HW-55167, "Heat Generation Rate in the NPR Graphite," E. R. Astley, February 27, 1958.

(6) HW-53542, "Selection of NPR Lattice Size", H. R. Kosmata, January 3, 1958.

(7) HW-56144, "Heat Generation in the NPR and K Reactor Thermal Shield", D. E. Wood, May 28, 1958.

(8) Letter, D. L. Condotta to G. L. Locke, dated March 7, 1958.

(9) HW-53544, "Maximum Activity Levels in NPR Heat Dissipation System", G. T. Orton and C. A. Mansius, January 20, 1958.

(10) HW-57252, "NPR Water Quality Design Bases", W. D. Bainard, August 13, 1958.

(11) HW-54202, "Preliminary Estimates of Stack and Stack-Gas Temperatures - NPR", R. F. Corlett, December 27, 1957.

(12) HW-55263, "NPR Shielding Prospectus", H. S. Davis, March 7, 1958.

Gardner L. Locke

Supervisor
Reactor Design Analysis Operation
IRRADIATION PROCESSING DEPARTMENT

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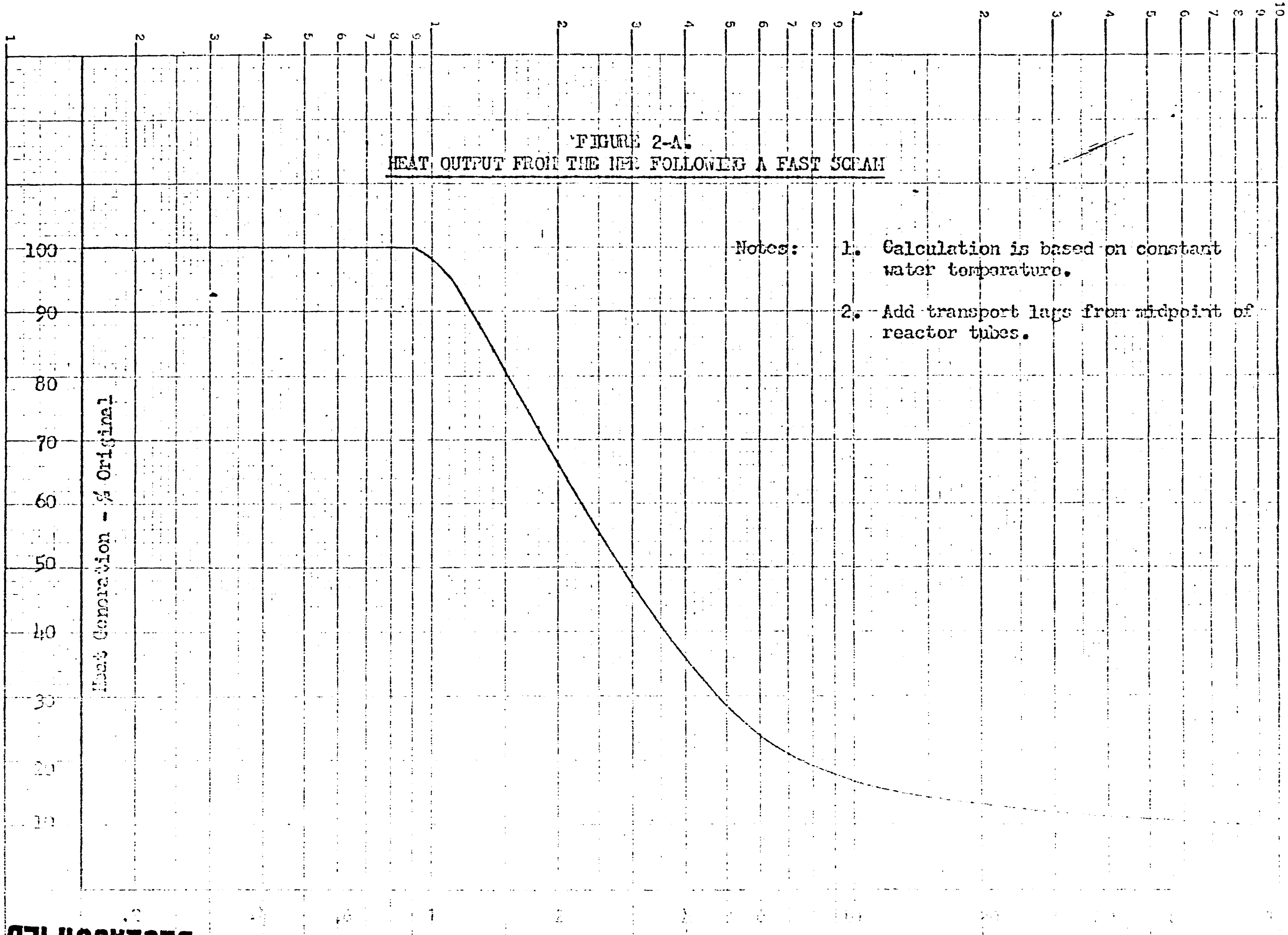

FIGURE 2-A.
HEAT OUTPUT FROM THE HER FOLLOWING A FAST SCRAM

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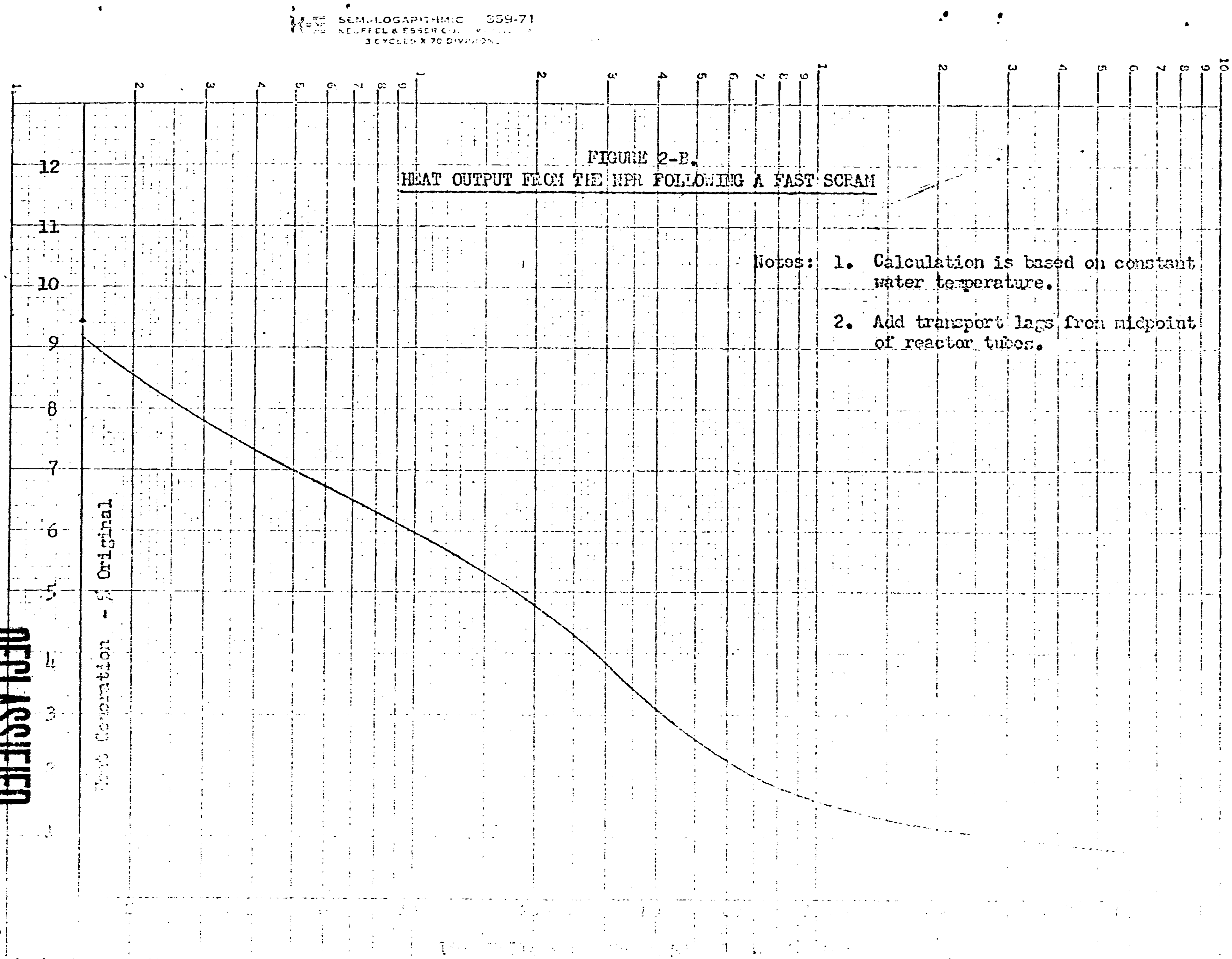

FIGURE 2-B.
HEAT OUTPUT FROM THE NPR FOLLOWING A FAST SCRAM

Notes: 1. Calculation is based on constant water temperature.

2. Add transport lags from midpoint of reactor tubes.

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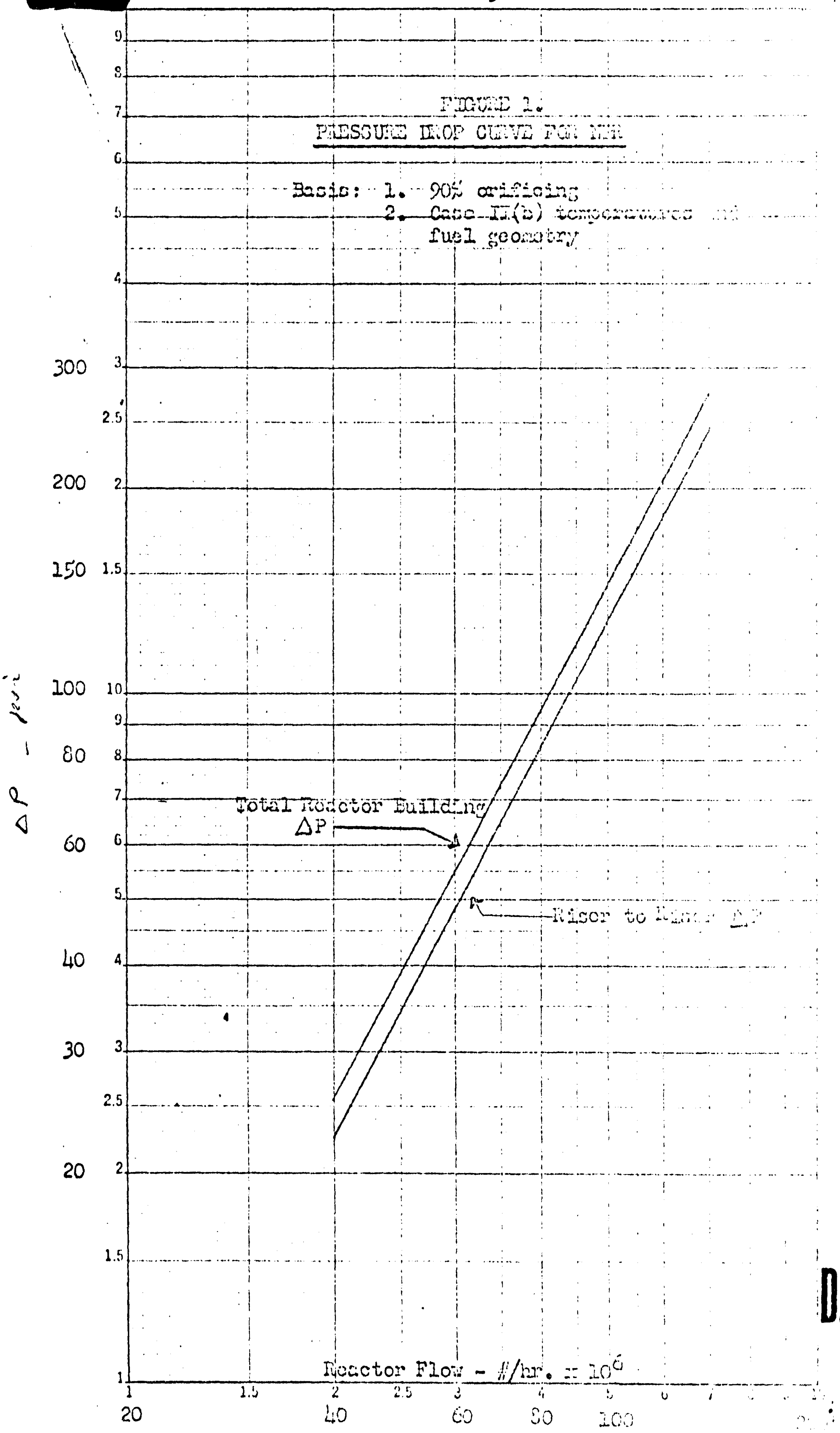

FIGURE 1.
PRESSURE DROP CURVE FOR [illegible]

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