CRITICALITY HANDBOOK

Volume II

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NOTICE

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DISCLAIMER

GENERAL CONTENTS

PREFACE

The use of the loose-leaf form for ARH-600 has permitted easy addition and modification of data. A loose-leaf notebook, however, can only be filled to the point at which ring holes begin to tear out because of restricted movement. The amount of data accumulated in the first volume of ARH-600 and new data expected to be added in the near future has required the expansion to two volumes, and the re-distribution of data between the two. The expansion into two volumes without overloading one has temporarily required division of data at a somewhat awkward location, the middle of Section III. However, completion of the U-233 part of Section III and the addition of data to Sections IV, V and VI as time permits, will probably require the addition of a third volume. At that time, it is hoped that the data can be redistributed more artistically.

III. HOMOGENEOUS SYSTEMS

A. PLUTONIUM SYSTEMS

B. URANIUM-235 SYSTEMS

C. URANIUM-233 SYSTEMS (SEE VOLUME III)

D. MIXED AND MISCELLANEOUS SYSTEMS (SEE VOLUME III)

III. HOMOGENEOUS DATA

A. PLUTONIUM SYSTEMS

1. Correlation Between Calculation and Experiment
2. H/Pu versus Plutonium g/l Relationship
3. Critical Sphere Dimensions

   Earlier graphs within this and following divisions have the percentage by weight of the major fissile atom (Pu-239) as the fourth identification number (e.g., III.A.3.97-2 would signify the second graph showing data for plutonium containing 97 weight percent Pu-239). Later graphs have been modified to set off the weight percent by parentheses, III.A.3(97)-2, in the interest of clarity.

4. Critical Cylinder Dimensions
5. Critical Slab Dimensions
6. Critical Mass - Sphere
7. Critical Mass per Unit Height - Cylinder
8. Critical Mass per Unit Area - Slab
9. Critical Volume
10. Material Bucklings and Infinite Multiplication Factor

BASIC PLUTONIUM CRITICAL PARAMETERS

Metal[2]	Full Reflection*	Bare
Minimum critical mass, kgs ^{239}Pu	5.425 ± .027[1]	10.2
Infinite cylinder, diameter inches	1.7	2.4
Infinite slab thickness, inches	0.28	1.1
Minimum spherical volume, liters	0.28	0.51

Homogeneous Solutions[3]	Full Reflection	Bare**
Minimum critical mass, g ^{239}Pu		
$^{239}Pu - H_2O$	531	
$^{239}Pu(NO_3)_4 - H_2O$	547	905
Infinite cylinders diameter, inches		
$^{239}Pu - H_2O$	***	***
$^{239}Pu(NO_3)_4 - H_2O$	6.41	9.15
Infinite Slab thickness, inches		
$^{239}Pu - H_2O$	***	***
$^{239}Pu(NO_3)_4 - H_2O$	2.44	5.30
Minimum spherical volume, liters		
$^{239}Pu - H_2O$	***	***
$^{239}Pu(NO_3)_4 - H_2O$	8.3	16.9
Minimum critical aqueous concentration, g/l ^{239}Pu	7.8 ± 0.3	(H/Pu = 3392 ± 100)

* Reflector is water unless specified otherwise.

** 0.125 inch thick stainless steel container shell.

*** There is no minimum value for theoretical Pu - H_2O solutions unless a maximum concentration is assumed, see pages III.A.4.100-3, III.A.5.100-3 and III.A.9.100-3.

(1) W. U. Geer, D. R. Smith, Measurement of the Critical Mass of a Water - Reflected Plutonium Sphere, ANS Transactions Vol. II No. 1, 1968.

(2) H. C. Paxton, J. T. Thomas, Dixon Callihan, E. B. Johnson, Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu and ^{233}U, TID-7028, 1964.

(3) C. R. Richey, Theoretical Analyses of Homogeneous Plutonium Critical Experiments, Nuclear Science and Engineering: 31, 32-39, 1968.

III.A.1 Correlations Between Calculation and Experiment

The primary means of producing the data in this section has been with the combination of the GAMTEC-II and HFN computer codes. The GAMTEC-II code was used to produce 18 neutron energy group cross-section sets which were then used in the HFN multigroup one-dimensional diffusion theory code to calculate critical sizes, extrapolation distances and material bucklings. A thorough analysis has been made by C. R. Richey[1] using this method to calculate the effective multiplication factor for critical experiments. A selection of these are produced below:

Geom.	Reflector	Pu g/l	% 240	Molarity	Calc. K_{eff}	Remarks
Sphere	Water	33.0	4.6	2.061	0.999	14 in. dia.
"	"	47.9	4.6	6.698	1.005	14 in. dia.
"	Bare	39.0	4.6	0.376	0.997	15.2 in. dia.
"	"	172.8	4.6	4.898	0.993	15.2 in. dia.
"	Water	26.33	0.54	0.806	0.998	14 in. dia.
"	"	28.63	0.54	2.553	0.997	14 in. dia.
"	"	73.0	4.6	0.165	1.001	11.2 in. dia.
"	"	140.0	4.6	2.238	1.001	11.2 in. dia.
"	"	268.0	4.6	1.084	1.001	11.2 in. dia.
Cyl.	"	44.7	1.5	2.058	0.9846	11.6 in. dia., ht.=12.28
"	"	45.45	1.5	2.094	0.9739	12.8 in. dia., ht.=10.34

(1) C. R. Richey, "Theoretical Analysis of Homogeneous Plutonium Critical Experiments," Nuclear Science and Engineering, January, 1968.

Richey found that as the height of the cylinders increased the agreement between theory and experiment became better, approaching a least-squares-fitted value of k_{eff} equal to 1.0086 for infinite cylinders.

The dimensions shown in Section III.A have been calculated with the GAMTEC II - HFN combination for k_{eff} equal to 1.00. The comparison with experiment shows that this can sometimes be slightly non-conservative. Dimensions which are less than critical with some degree of confidence can be obtained by reducing the calculated critical values to values equivalent to k_{eff} equal to 0.986 for spheres and 0.980 for infinite slabs and cylinders. (See page II.B.1-6) Critically favorable values can be obtained by adjusting the critical values by the appropriate safety factor given in Section I.C.

The buckling and extrapolation distance curves (Section A.10) are derived from GAMTEC II - HFN calculations and can be used for calculating general geometries other than those represented by the curves for the simple sphere, infinite cylinder and infinite slab. It might be noted that the use of the buckling and extrapolation distance curves for these simple geometries may give a somewhat smaller critical dimension than the geometry data shows. Since each geometry has a slightly different extrapolation distance for the same plutonium concentration, the graphing of all data would result in an unreadable mess of lines. Therefore, only the most limiting extrapolation distances were used in Section A.10 for each particular solution.

III.A.2. H/Pu versus Pu g/l Relationships

The following relationships were used for the adjoining graph.

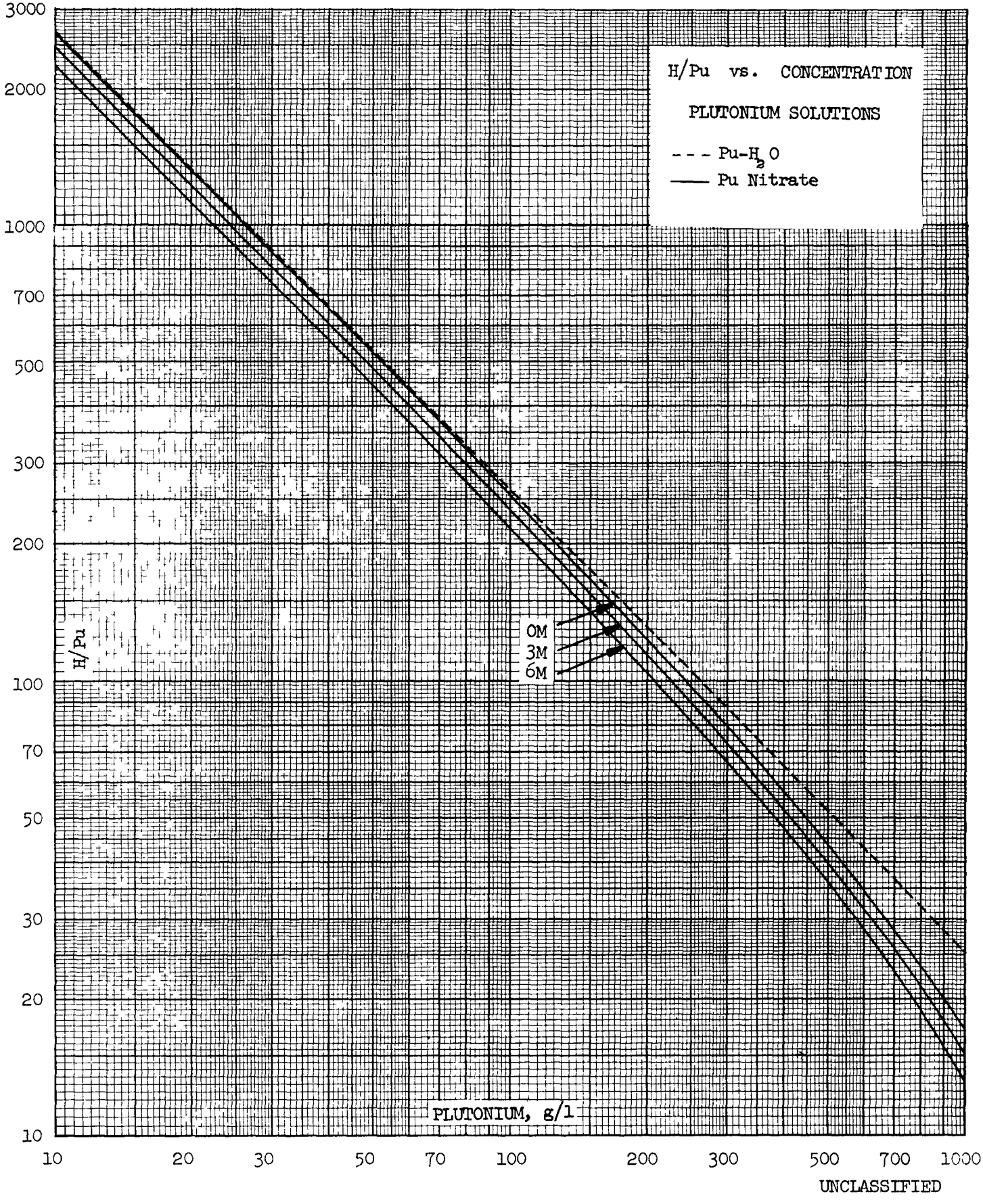
For Pu nitrate solutions:

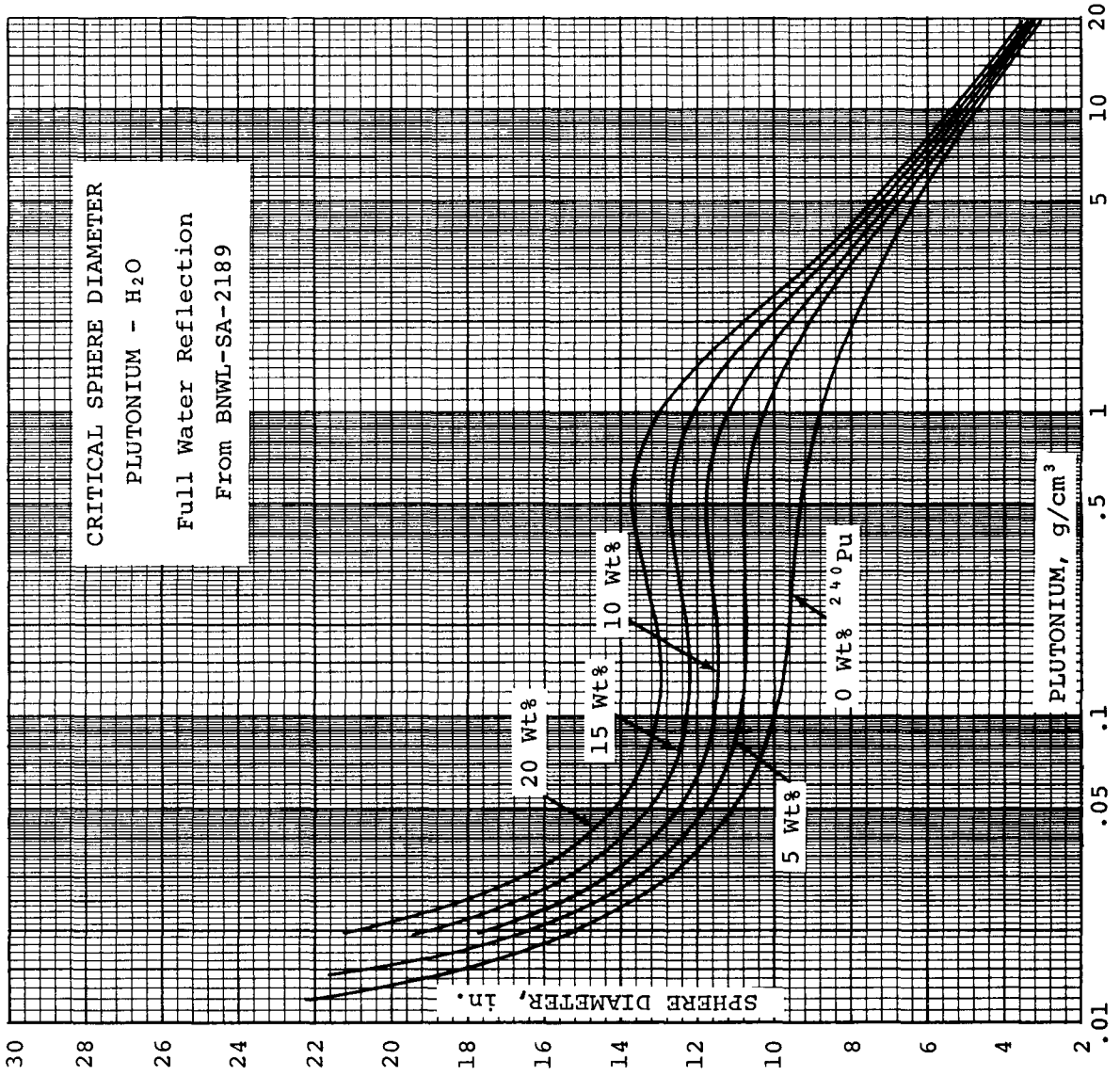
$$H/Pu = \left[\frac{26{,}539 - 638.7 \times \text{Molarity of Excess Nitric Acid}}{\text{Pu g/l}}\right] - 9.606$$

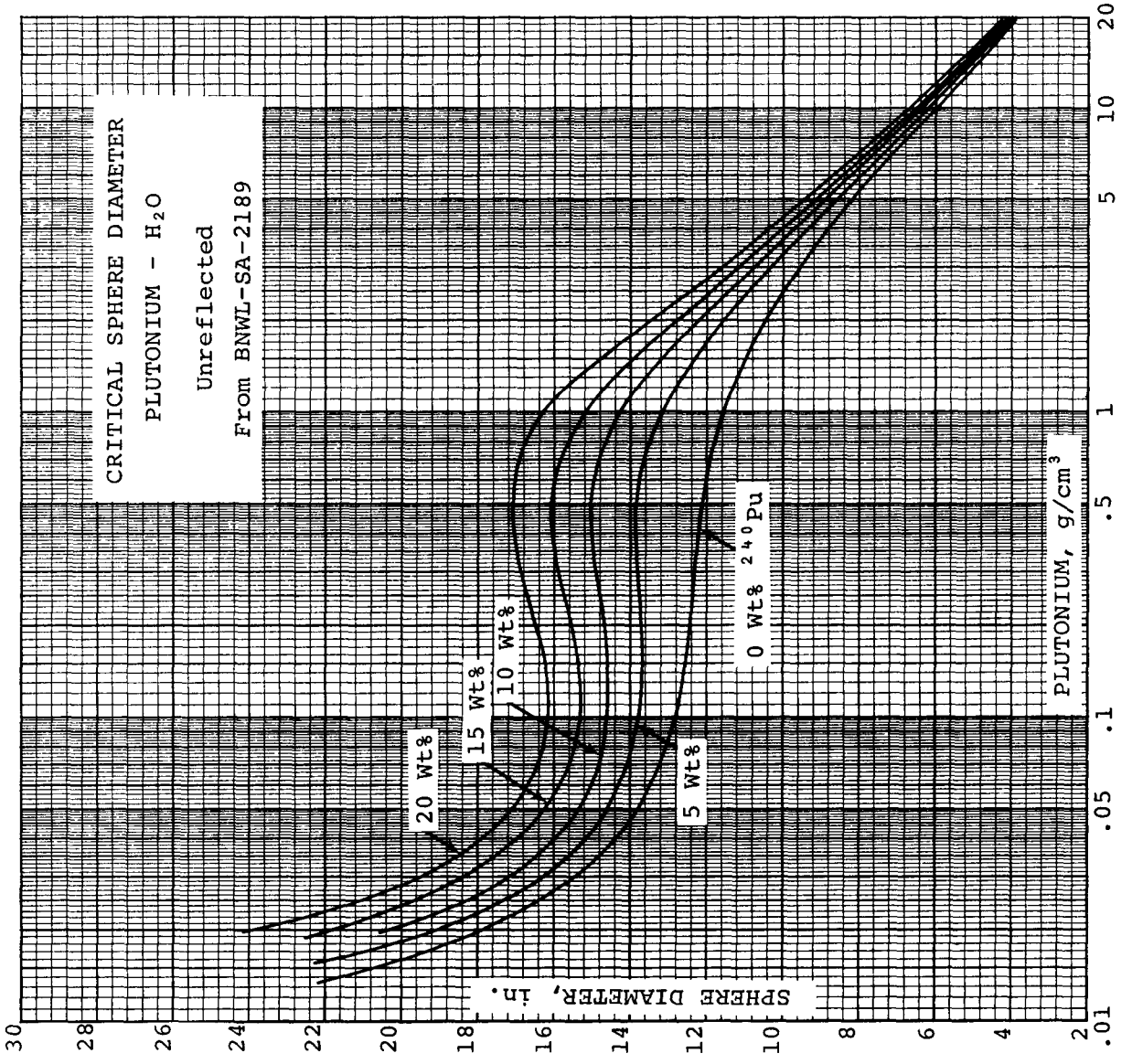
This equation was derived from work performed by C. R. Richey and G. M. Hess.

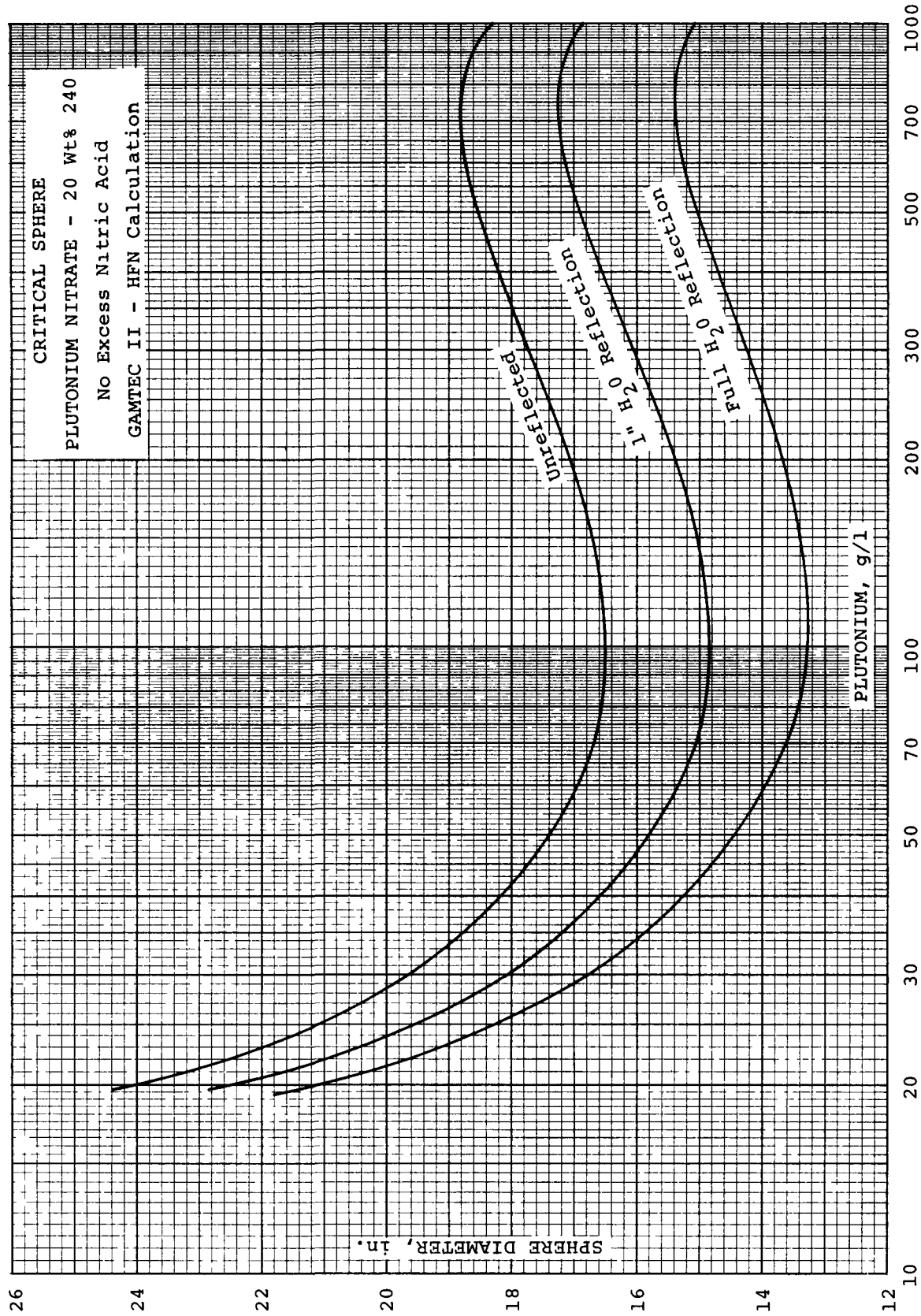
For Pu-H_2O solutions:

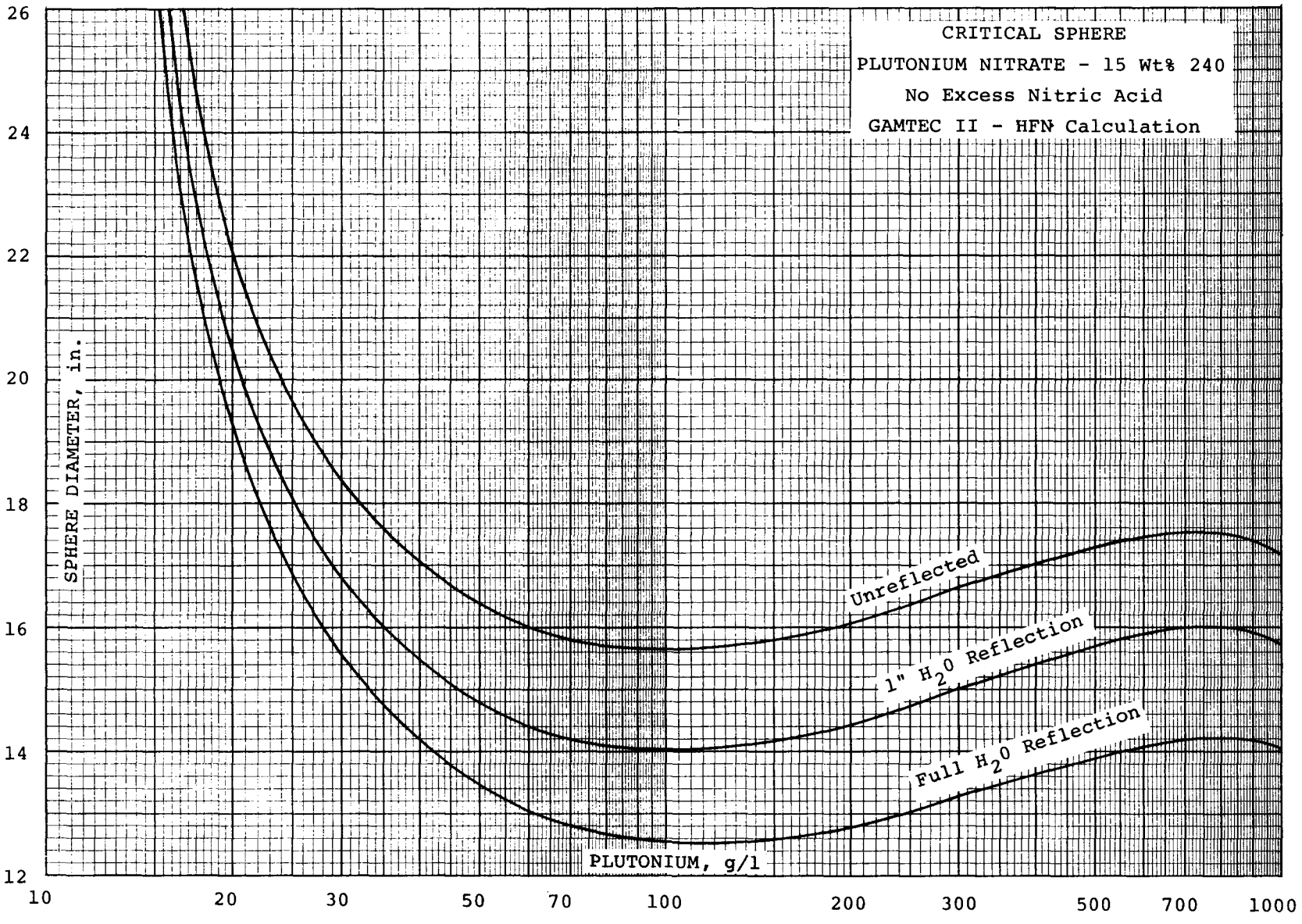
$$H/Pu = \left[\frac{26{,}530}{\text{Pu g/l}}\right] - 1.35$$

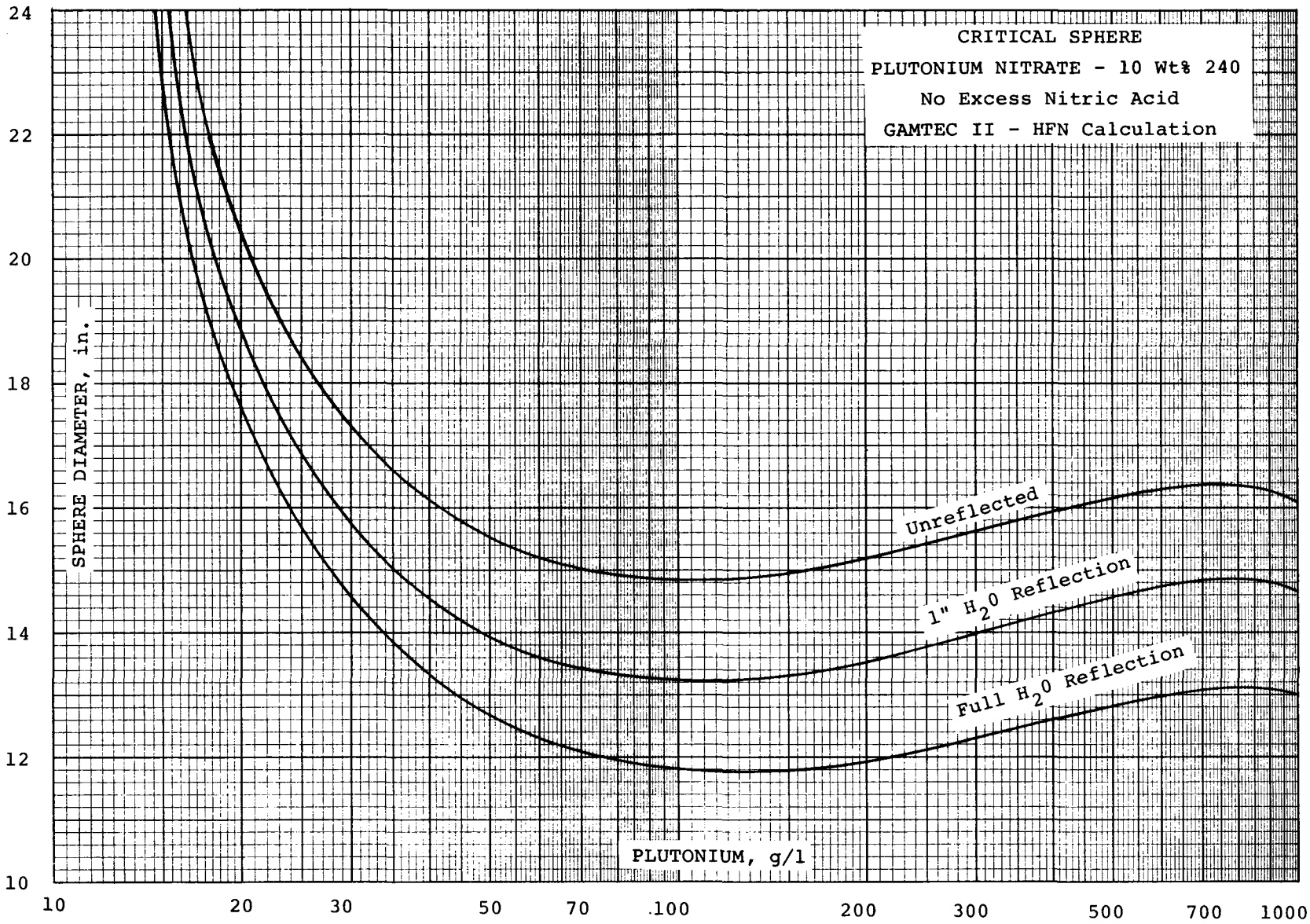

H/Pu vs. CONCENTRATION
PLUTONIUM SOLUTIONS
--- Pu-H2O
—— Pu Nitrate
0M
3M
6M
H/Pu
PLUTONIUM, g/l
3000
2000
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

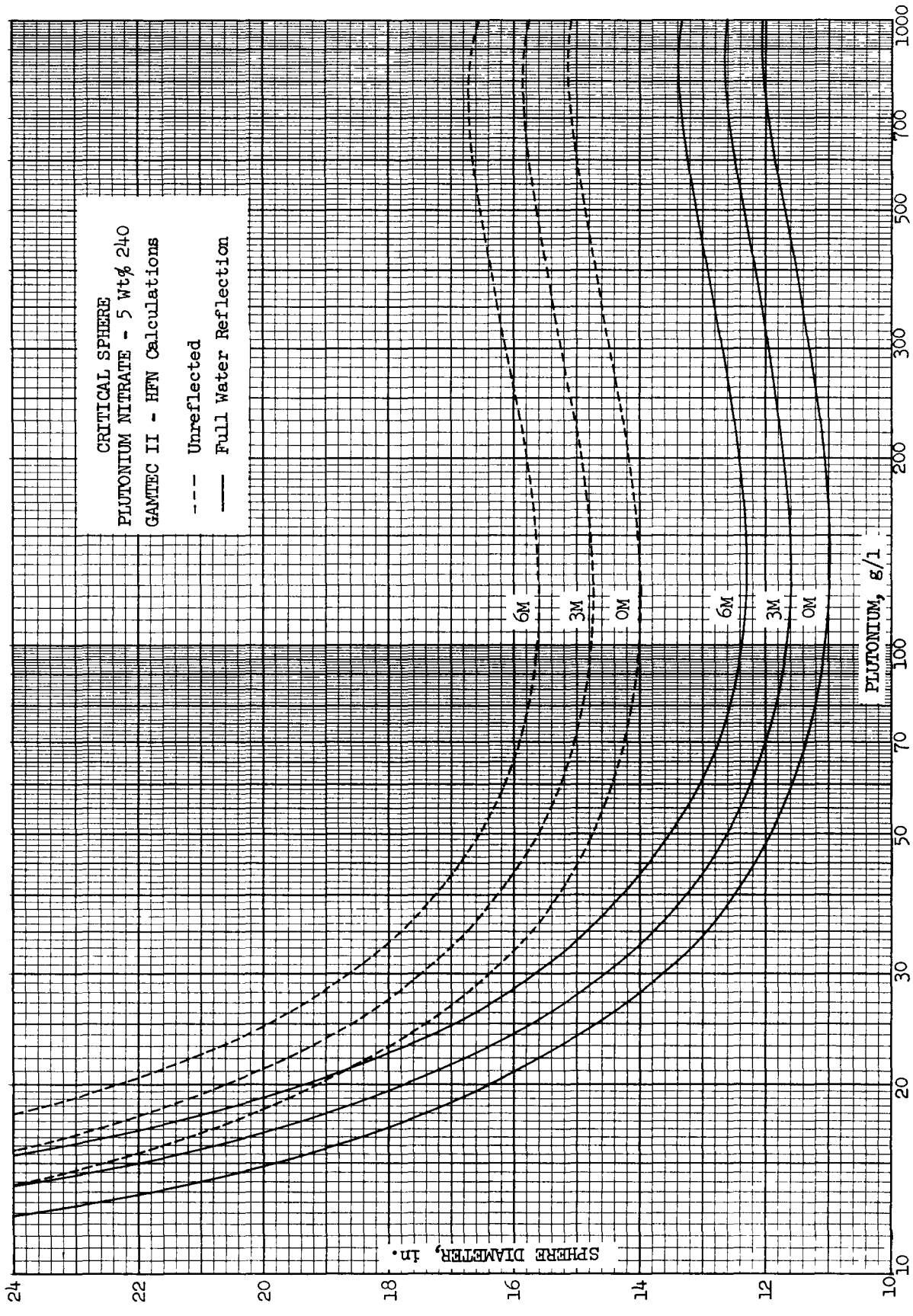

CRITICAL SPHERE DIAMETER
PLUTONIUM - H_2O
Full Water Reflection
From BNWL-SA-2189
SPHERE DIAMETER, in.
PLUTONIUM, g/cm³
0 Wt% ^{240}Pu
5 Wt%
10 Wt%
15 Wt%
20 Wt%
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
.01
.05
.1
.5
1
5
10
20

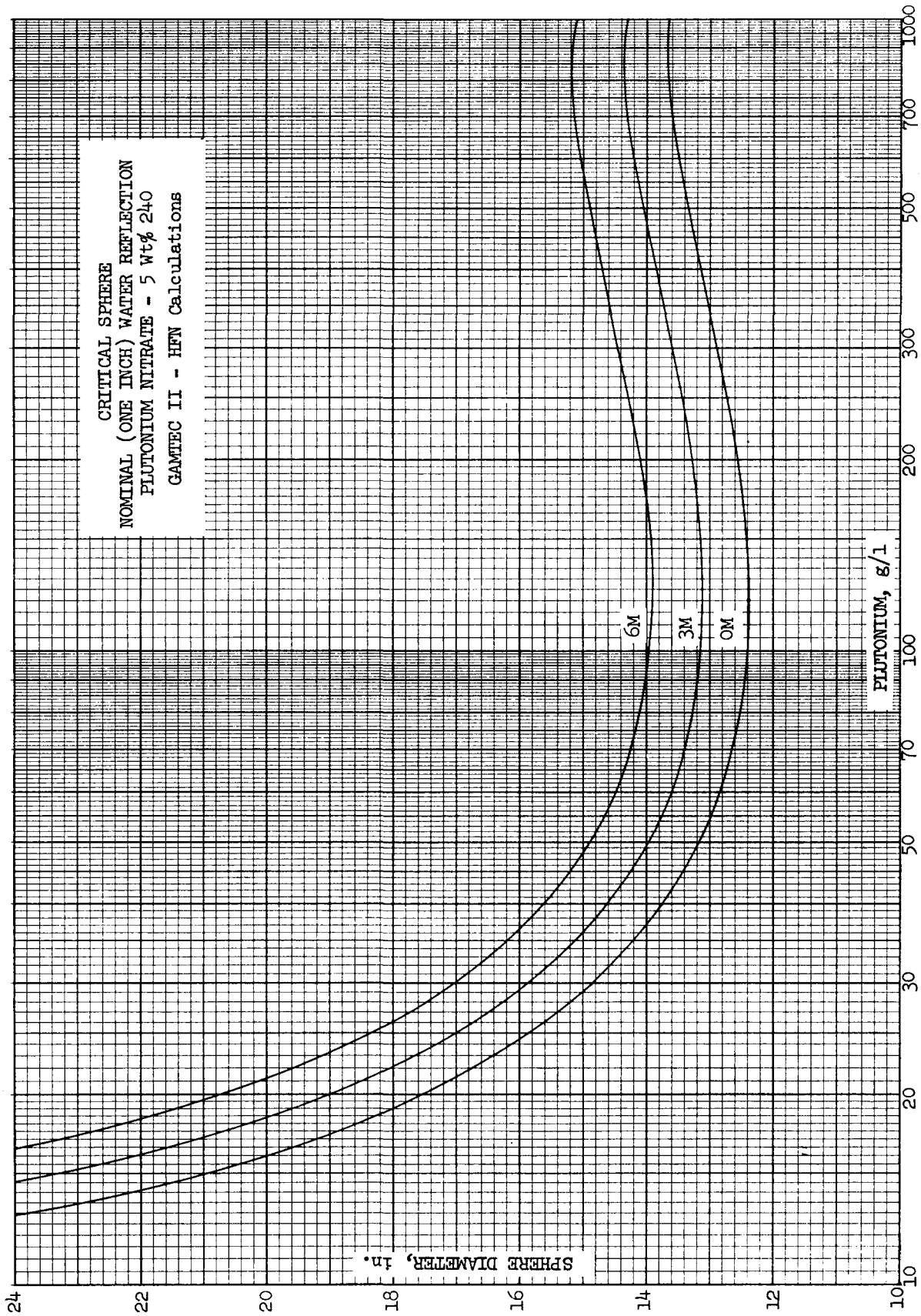

CRITICAL SPHERE DIAMETER
PLUTONIUM - H_2O
Unreflected
From BNWL-SA-2189
SPHERE DIAMETER, in.
PLUTONIUM, g/cm³
0 Wt% ^{240}Pu
5 Wt%
10 Wt%
15 Wt%
20 Wt%
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
.01
.05
.1
.5
1
5
10
20

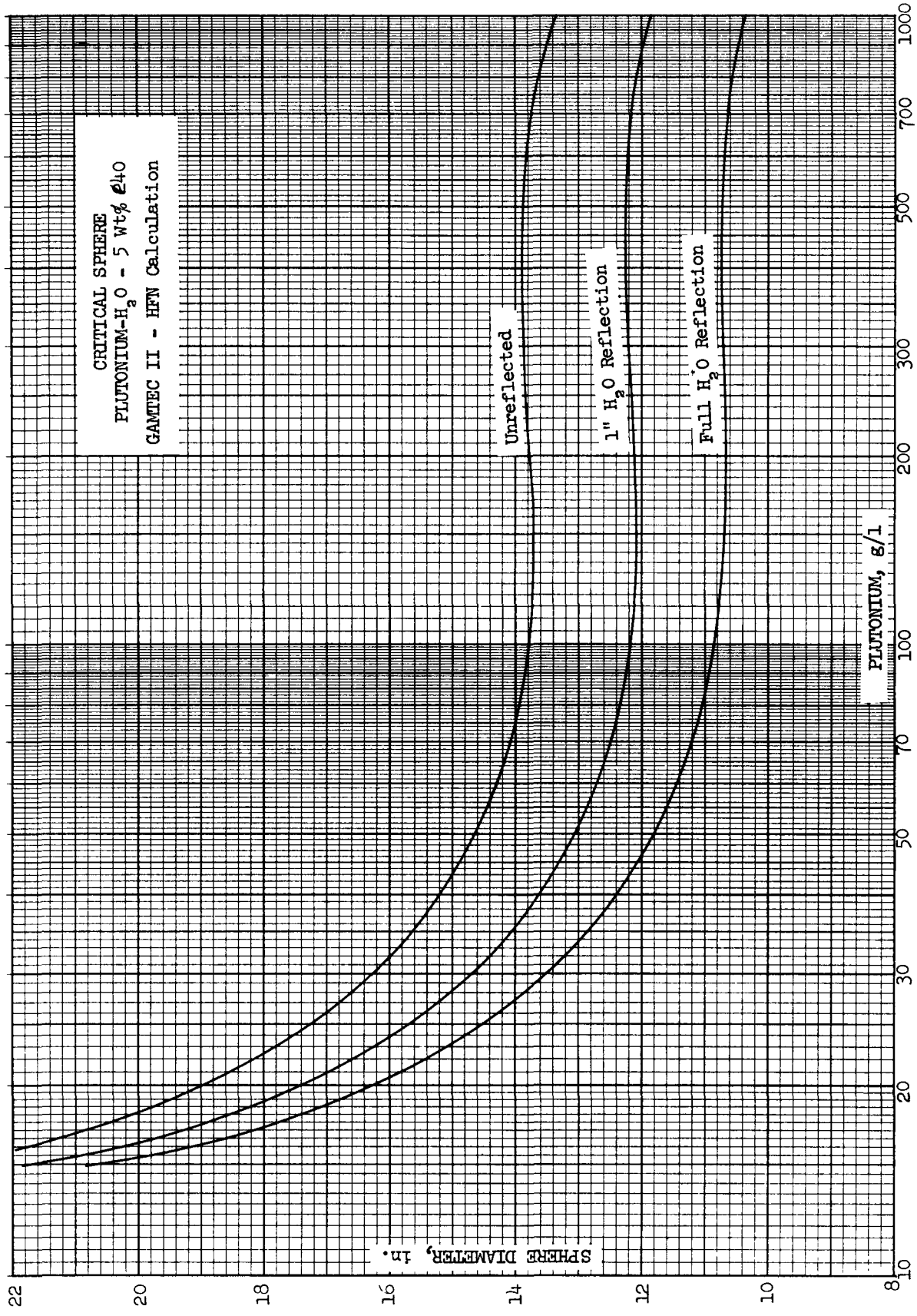

CRITICAL SPHERE
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
PLUTONIUM, g/l
SPHERE DIAMETER, in.
10
20
30
50
70
100
200
300
500
700
1000
26
24
22
20
18
16
14
12

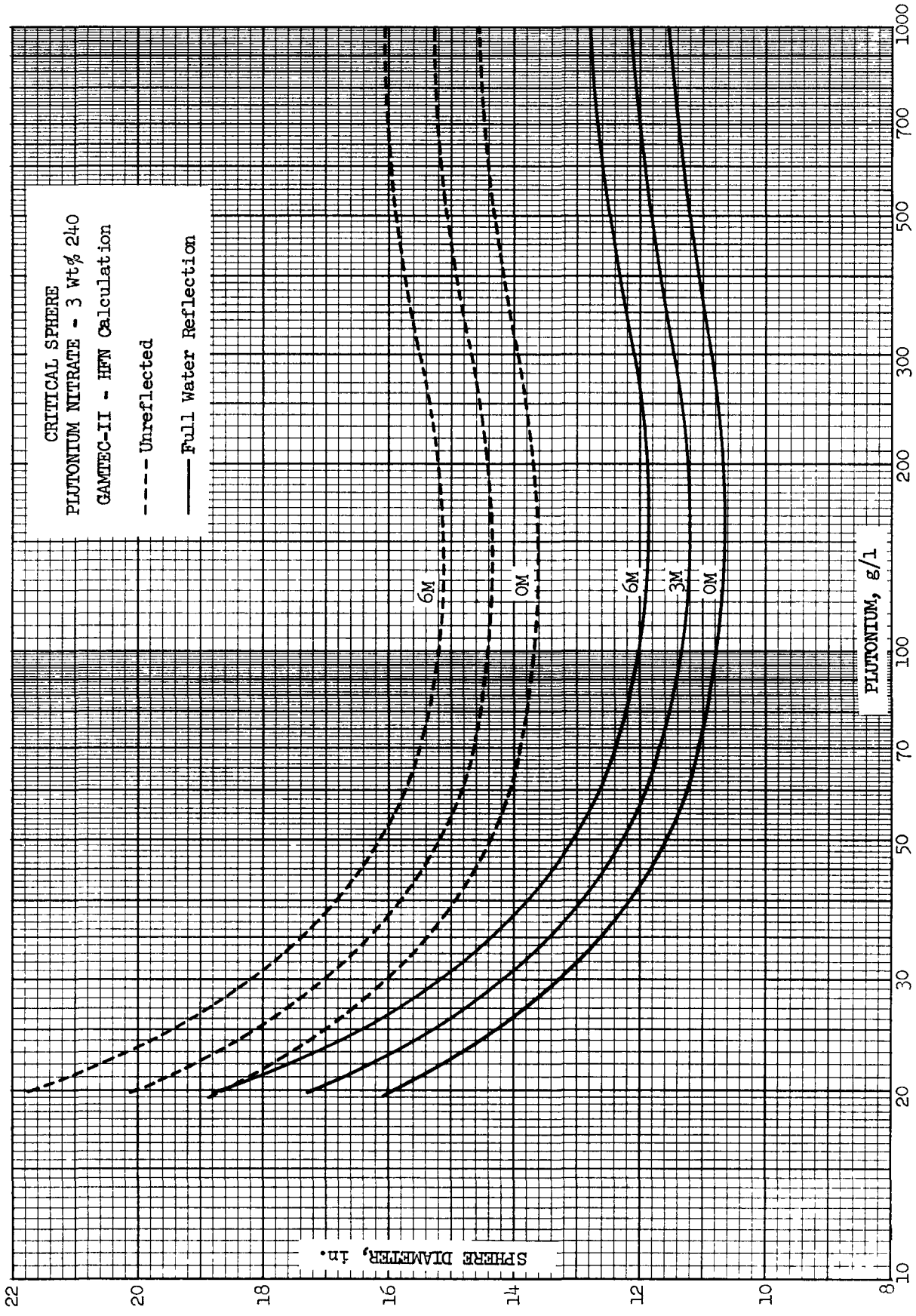

CRITICAL SPHERE
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
SPHERE DIAMETER, in.
PLUTONIUM, g/l
Unreflected
1" H_2O Reflection
Full H_2O Reflection
26
24
22
20
18
16
14
12
10
20
30
50
70
100
200
300
500
700
1000

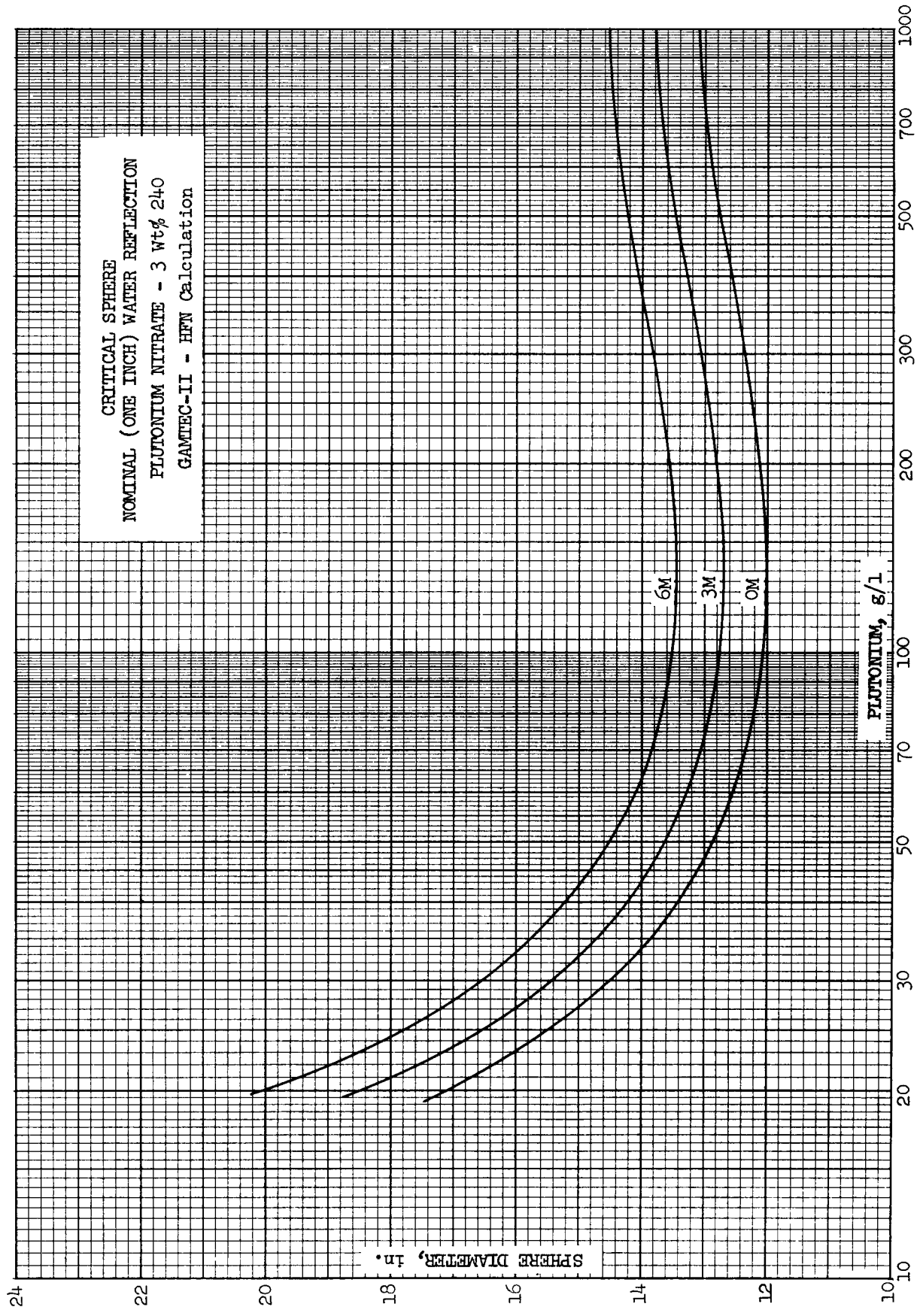

CRITICAL SPHERE
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
SPHERE DIAMETER, in.
PLUTONIUM, g/l
Unreflected
1" H2O Reflection
Full H2O Reflection
24
22
20
18
16
14
12
10
10
20
30
50
70
100
200
300
500
700
1000

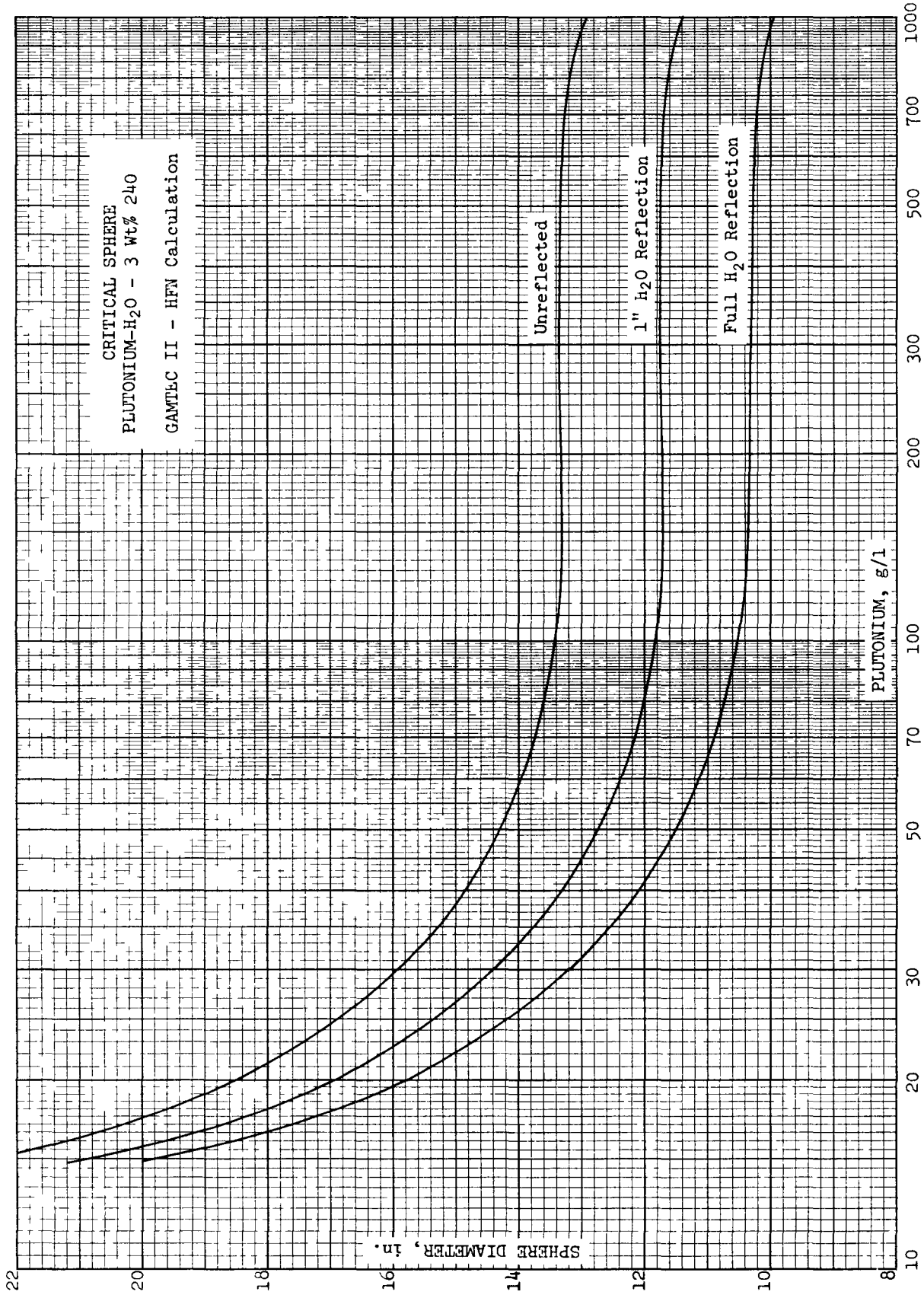

CRITICAL SPHERE
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculations
--- Unreflected
—— Full Water Reflection
6M
3M
0M
6M
3M
0M
PLUTONIUM, g/l
SPHERE DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
24
22
20
18
16
14
12
10

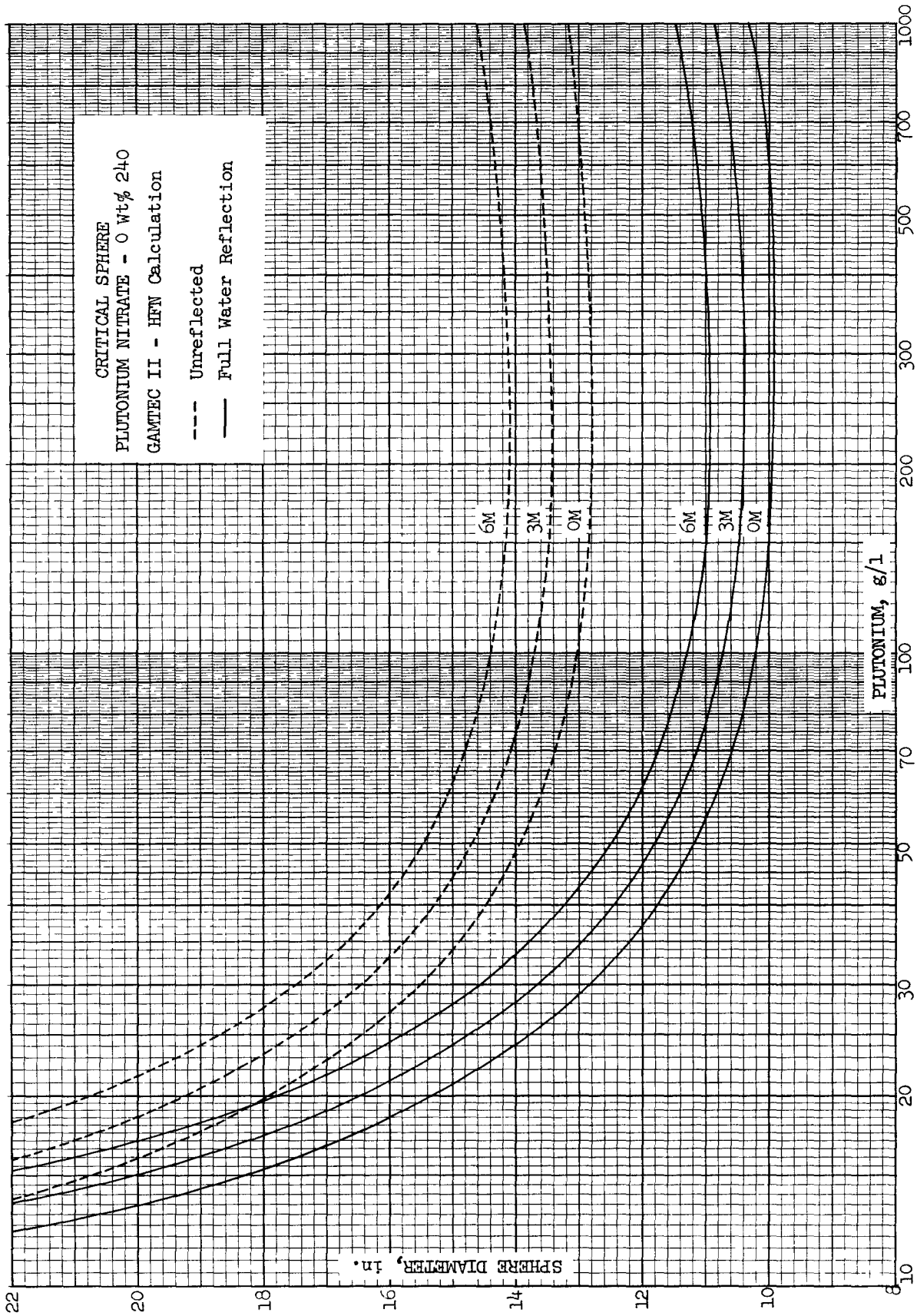

CRITICAL SPHERE
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculations
6M
3M
0M
PLUTONIUM, g/l
SPHERE DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
24
22
20
18
16
14
12
10

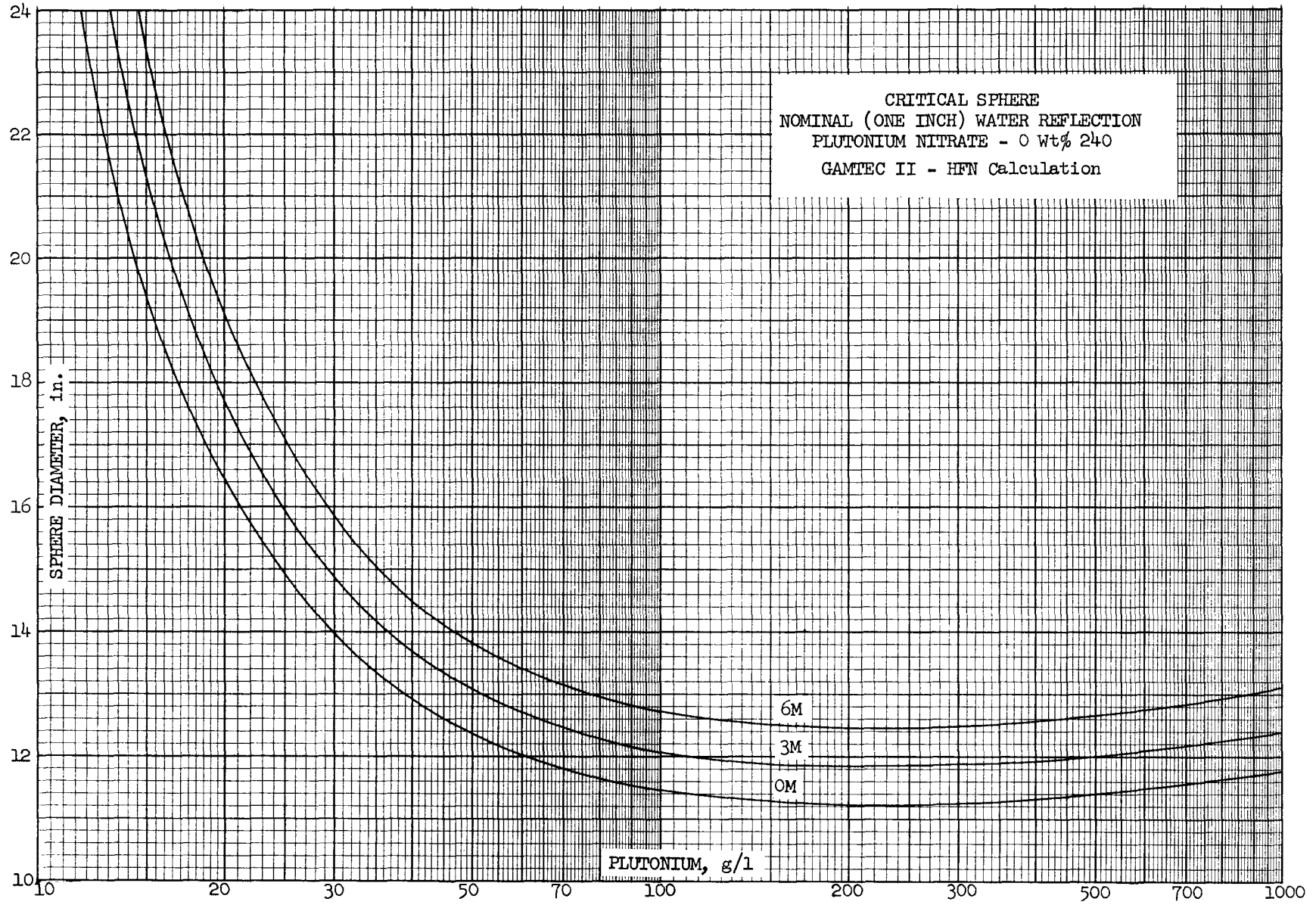

CRITICAL SPHERE
PLUTONIUM-H_2O - 5 wt% e^{40}
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
PLUTONIUM, g/l
SPHERE DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
8
22
20
18
16
14
12
10


CRITICAL SPHERE
PLUTONIUM NITRATE - 3 wt% 240
GAMTEC-II - HFN Calculation
---- Unreflected
—— Full Water Reflection
6M
0M
6M
3M
0M
PLUTONIUM, g/l
SPHERE DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
22
20
18
16
14
12
10
8


CRITICAL SPHERE
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-II - HFN Calculation
6M
3M
0M
PLUTONIUM, g/l
SPHERE DIAMETER, in.
10
12
14
16
18
20
22
24
10
20
30
50
70
100
200
300
500
700
1000


CRITICAL SPHERE
PLUTONIUM-H2O - 3 Wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H2O Reflection
Full H2O Reflection
SPHERE DIAMETER, in.
PLUTONIUM, g/l
22
20
18
16
14
12
10
8
1000
700
500
300
200
100
70
50
30
20
10


CRITICAL SPHERE
PLUTONIUM NITRATE - 0 wt% 240
GAMTEC II - HFN Calculation
--- Unreflected
—— Full Water Reflection
6M
3M
0M
6M
3M
0M
SPHERE DIAMETER, in.
PLUTONIUM, g/l
22
20
18
16
14
12
10
8
1000
700
500
300
200
100
70
50
30
20
10


CRITICAL SPHERE
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Calculation
SPHERE DIAMETER, in.
PLUTONIUM, g/l
6M
3M
0M
24
22
20
18
16
14
12
10
10
20
30
50
70
100
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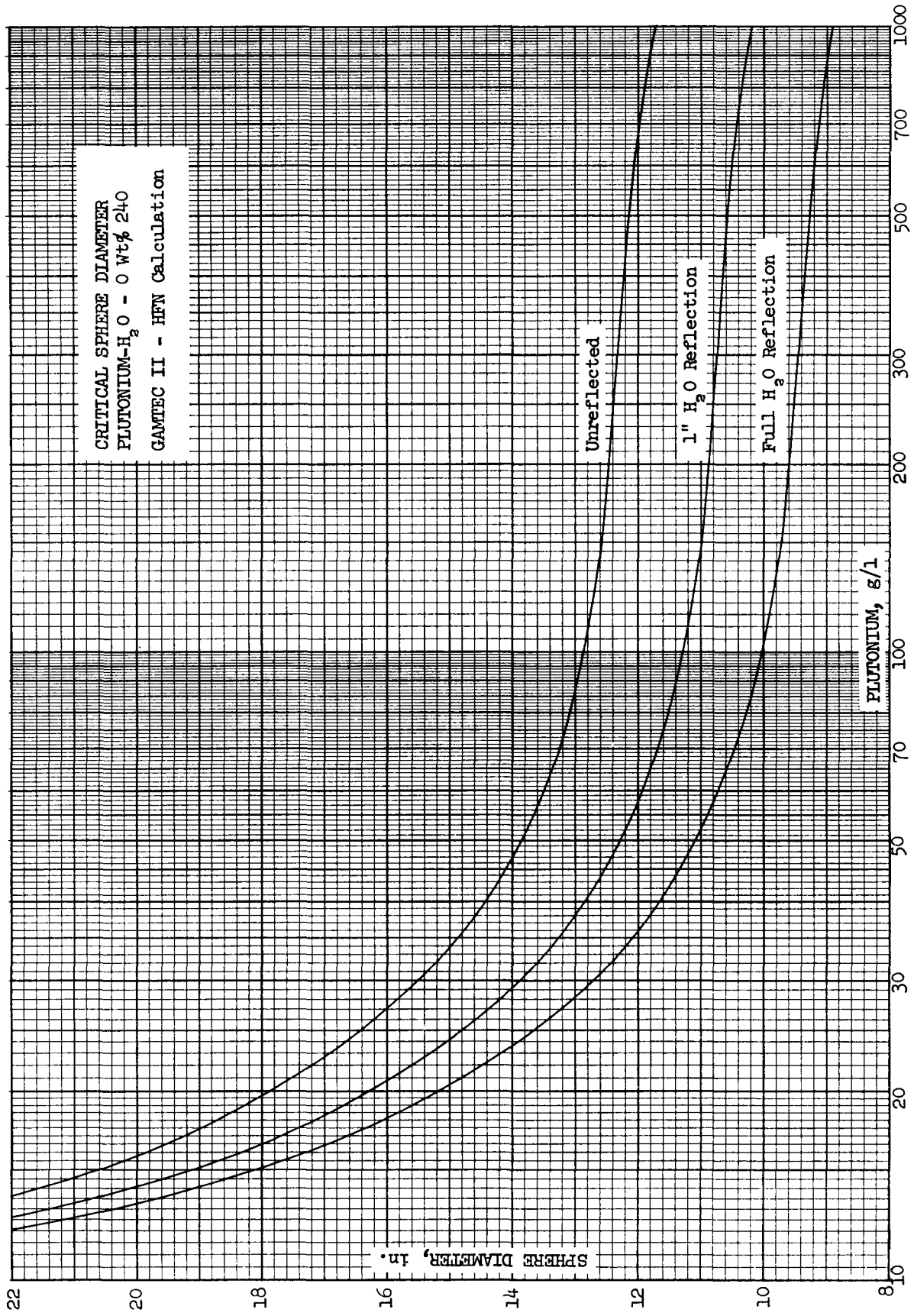
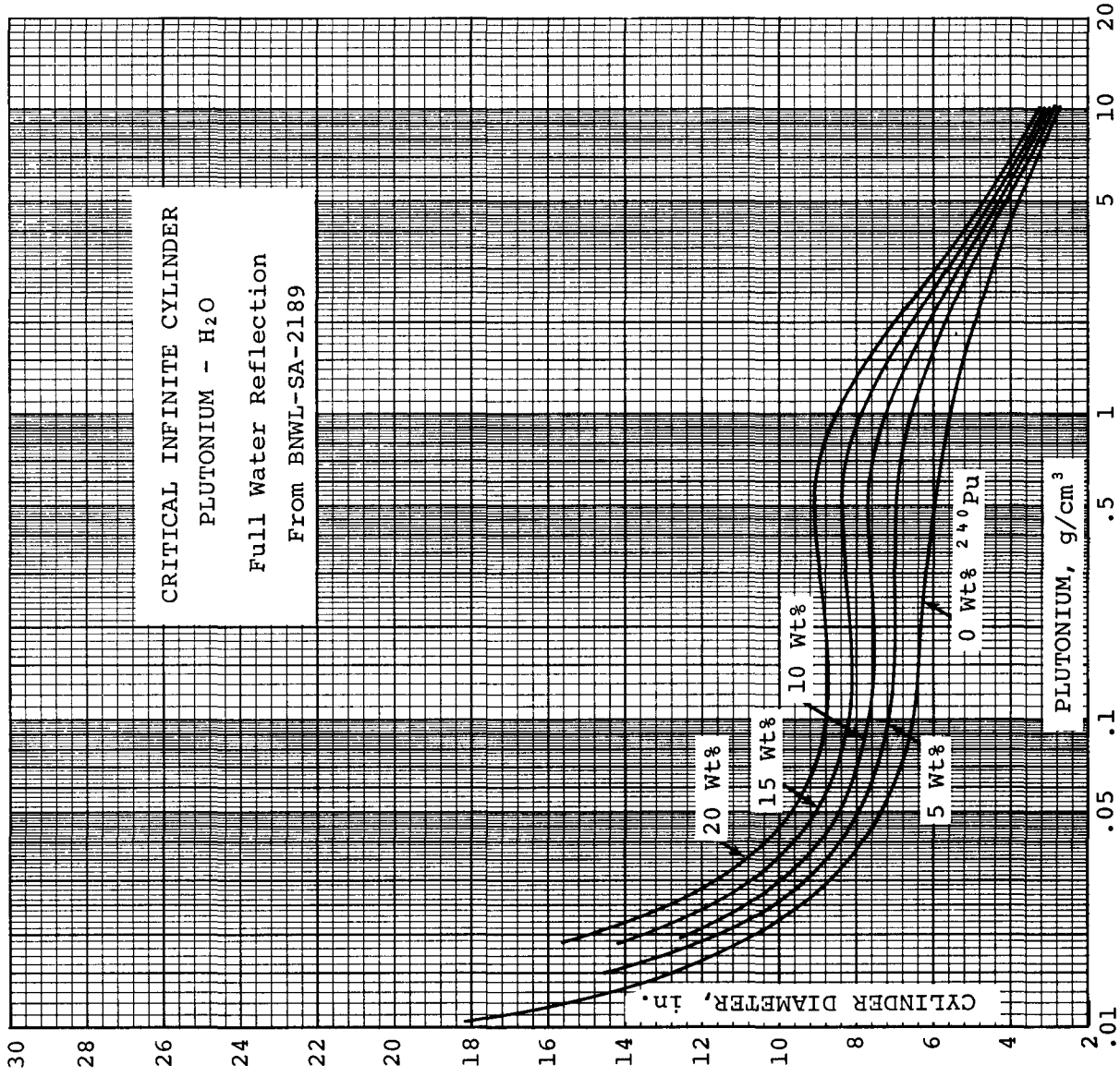
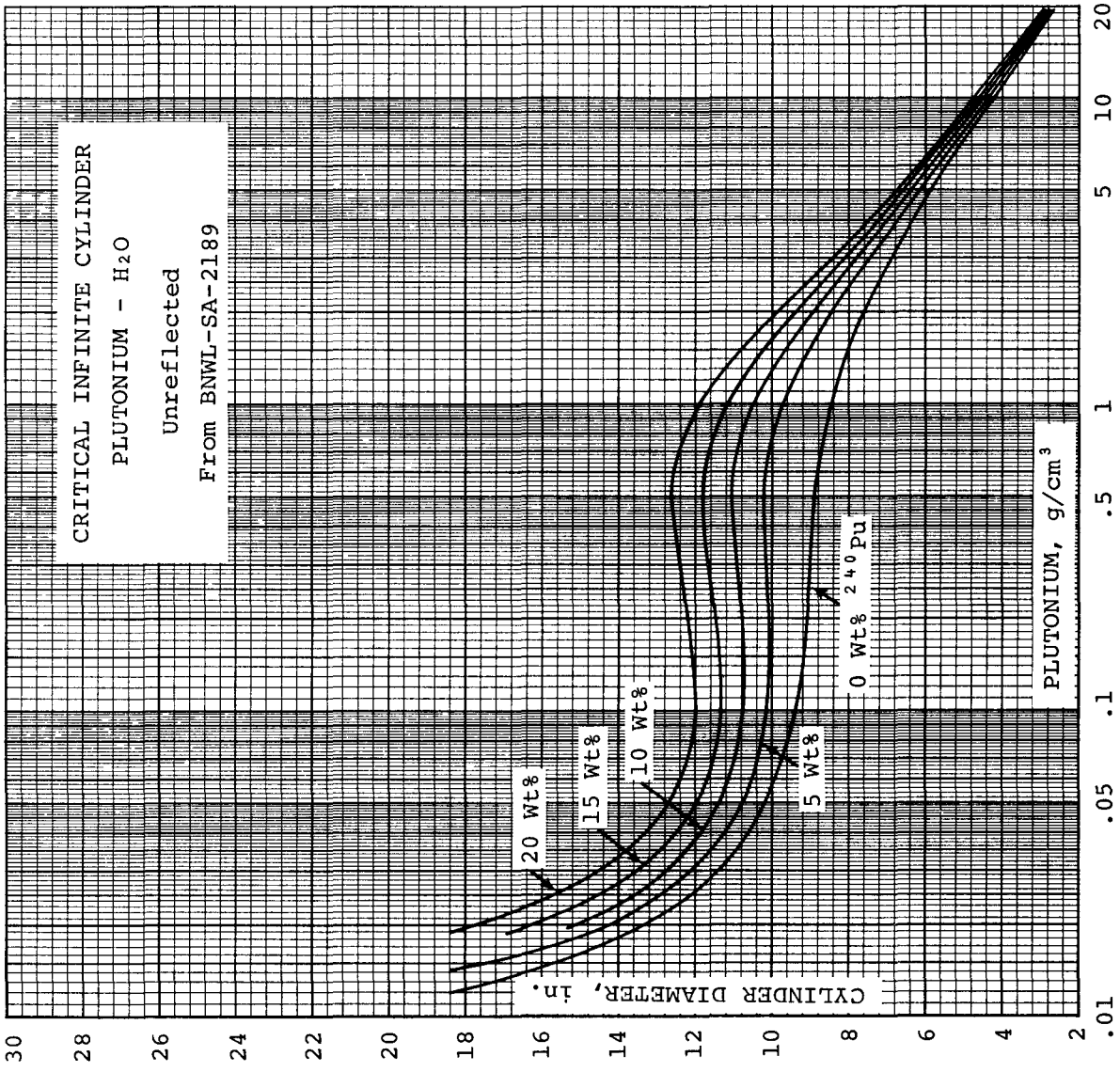
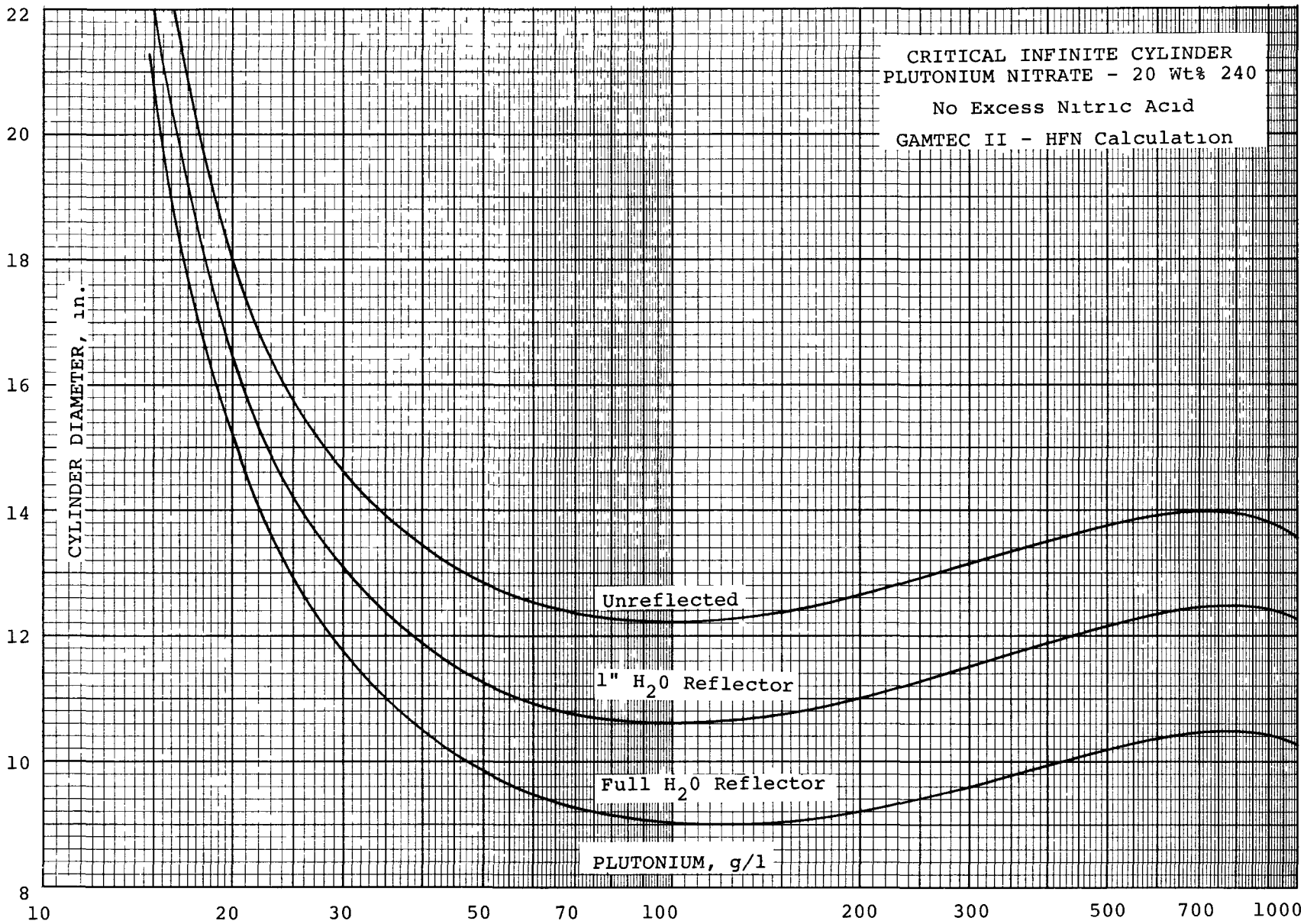
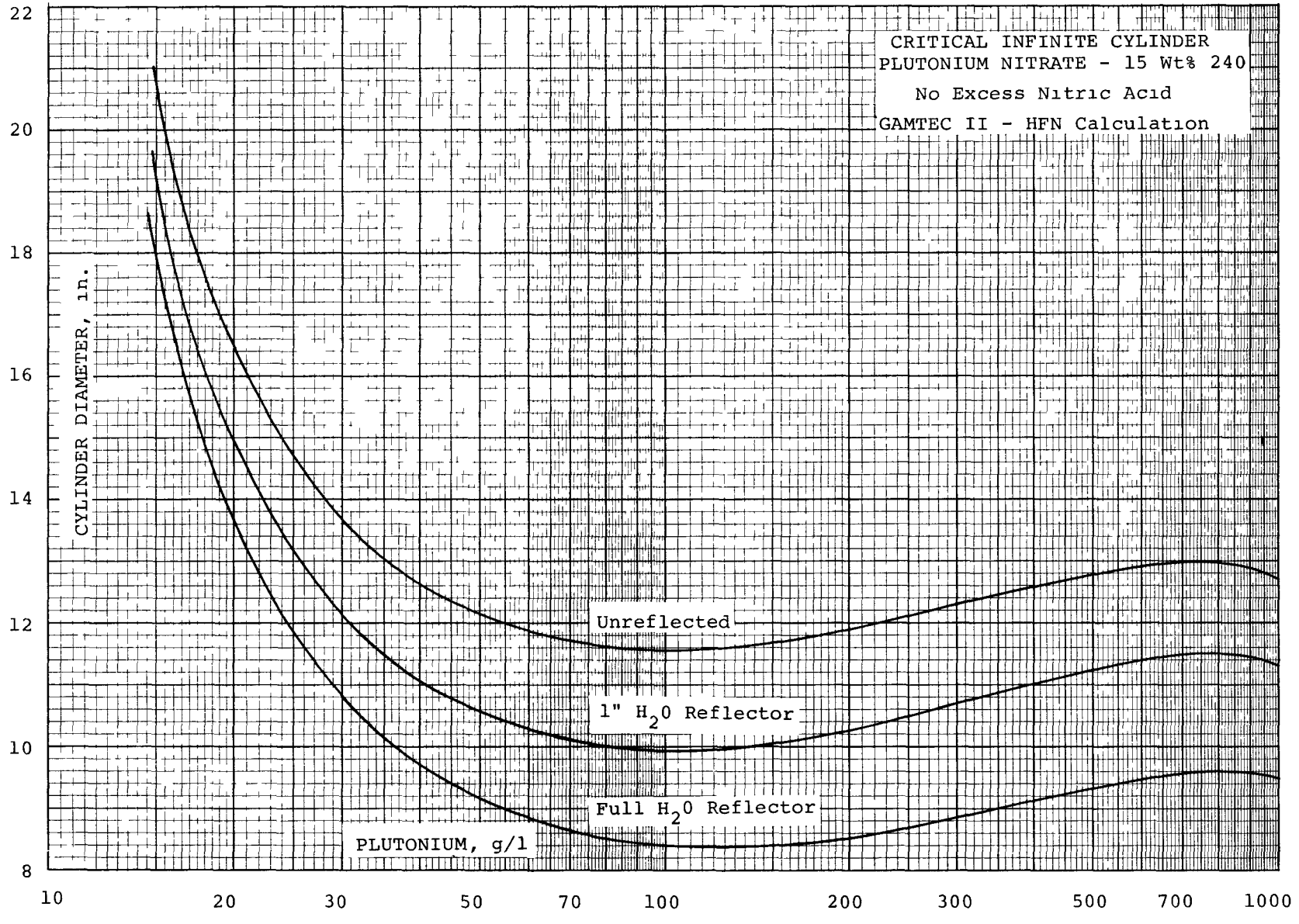
500
700
1000

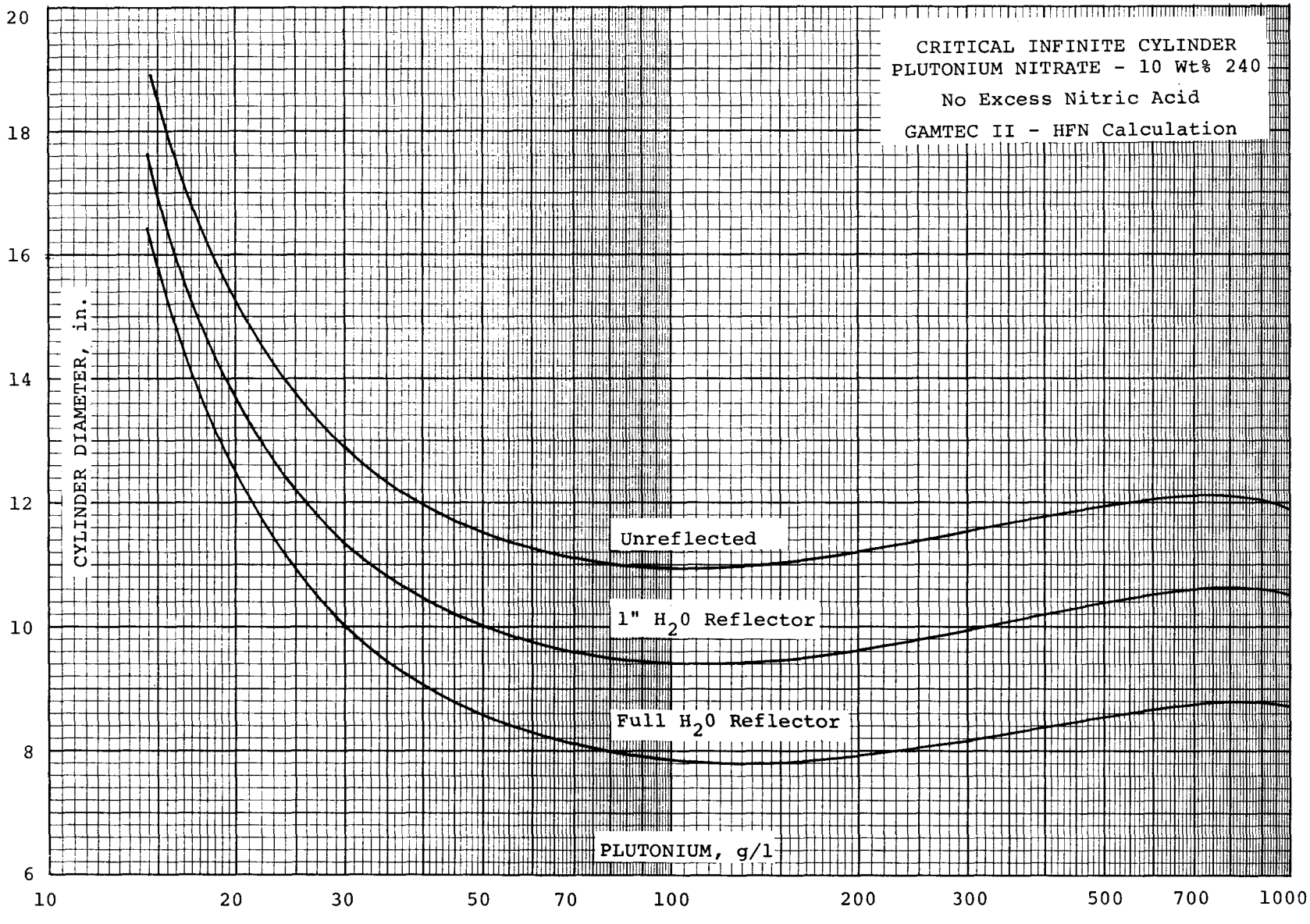

CRITICAL SPHERE DIAMETER
PLUTONIUM-H_2O - 0 Wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
PLUTONIUM, g/l
SPHERE DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
22
20
18
16
14
12
10
8

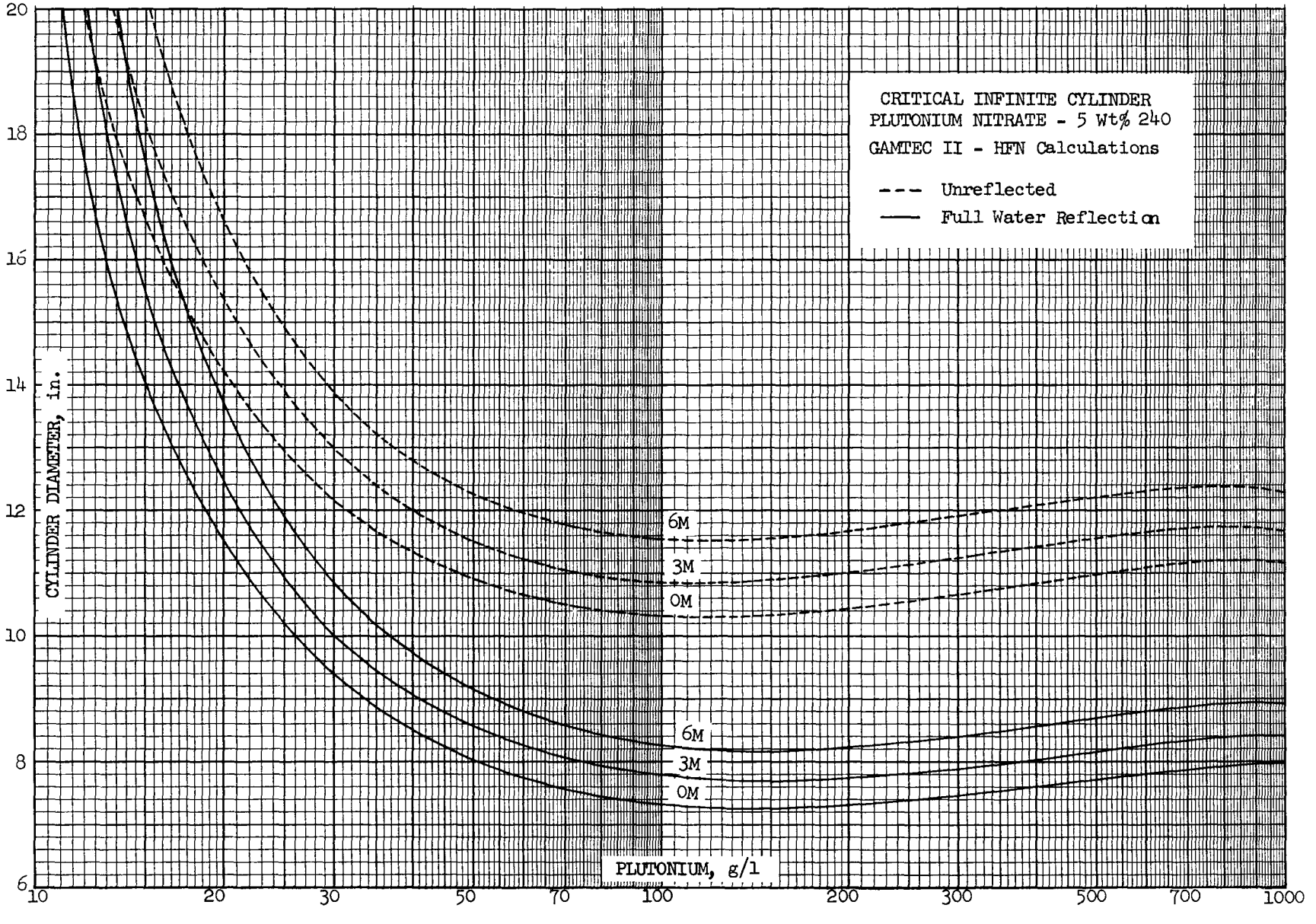

CRITICAL INFINITE CYLINDER
PLUTONIUM - H_2O
Full Water Reflection
From BNWL-SA-2189
CYLINDER DIAMETER, in.
PLUTONIUM, g/cm^3
20 Wt% ^{240}Pu
15 Wt%
10 Wt%
5 Wt%
0 Wt% ^{240}Pu
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
.01
.05
.1
.5
1
5
10
20

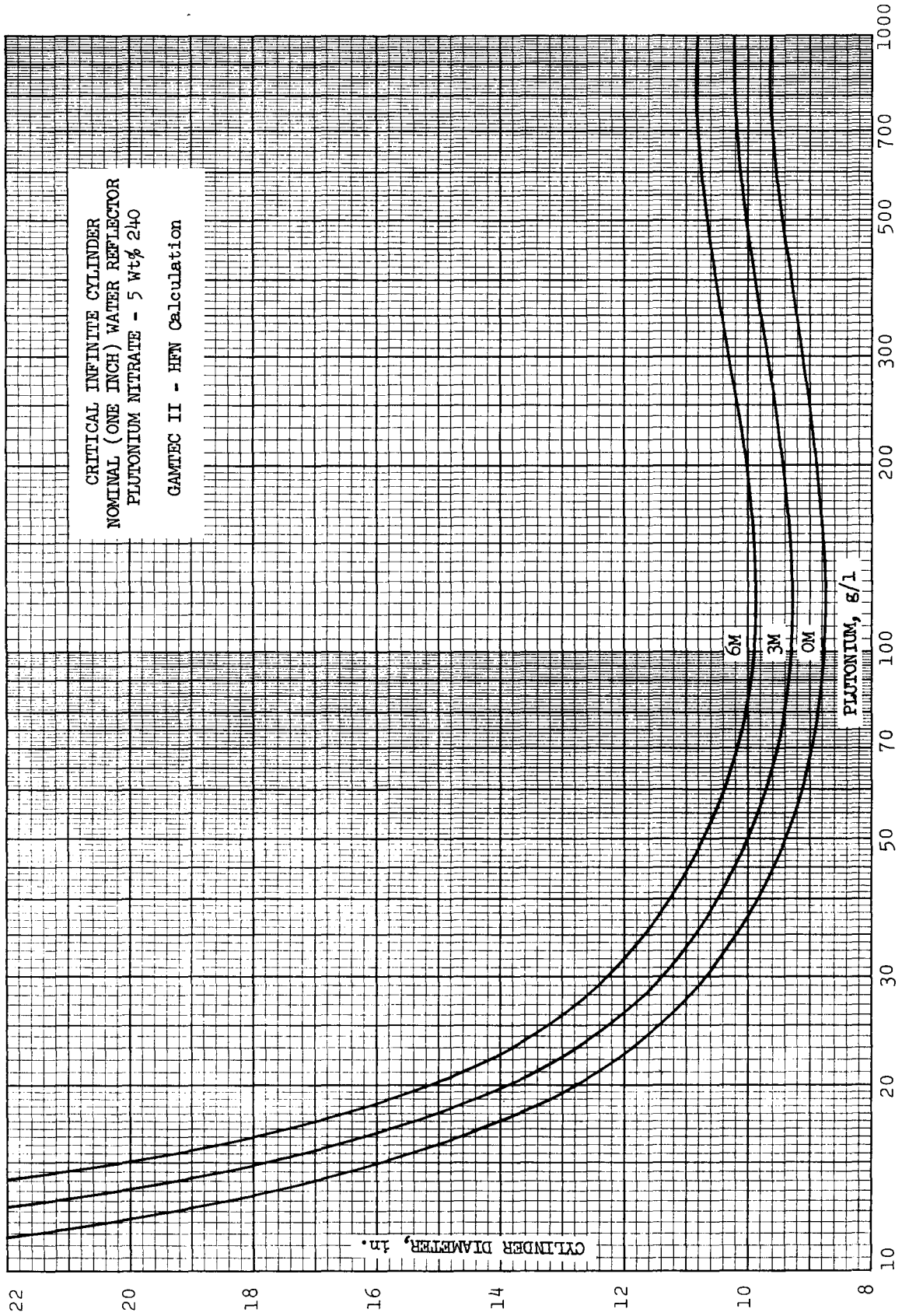

CRITICAL INFINITE CYLINDER
PLUTONIUM - H_2O
Unreflected
From BNWL-SA-2189
CYLINDER DIAMETER, in.
PLUTONIUM, g/cm³
0 Wt% ^{240}Pu
5 Wt%
10 Wt%
15 Wt%
20 Wt%
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
.01
.05
.1
.5
1
5
10
20

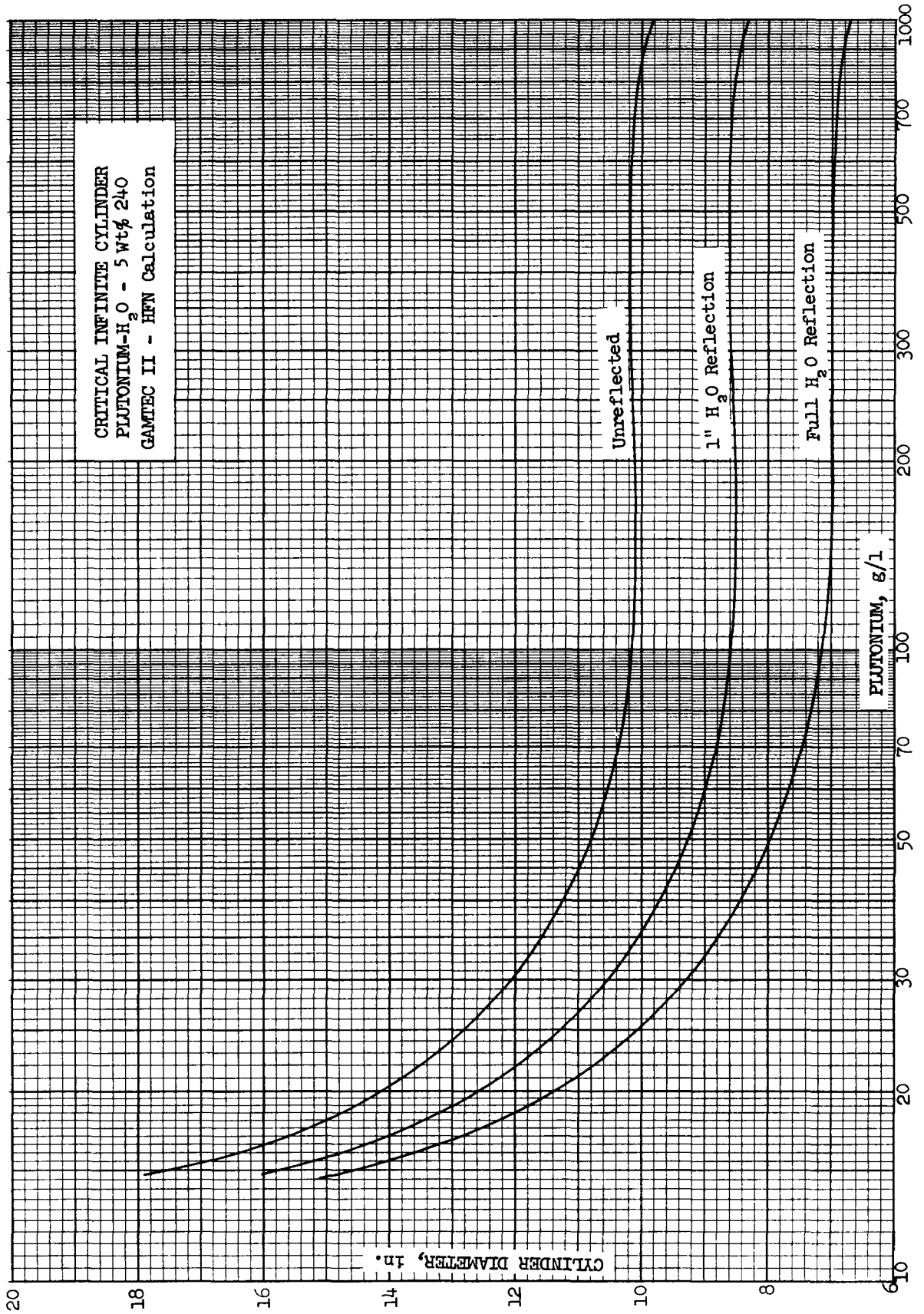

CRITICAL INFINITE CYLINDER
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
CYLINDER DIAMETER, in.
22
20
18
16
14
12
10
8
Unreflected
1" H2O Reflector
Full H2O Reflector
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

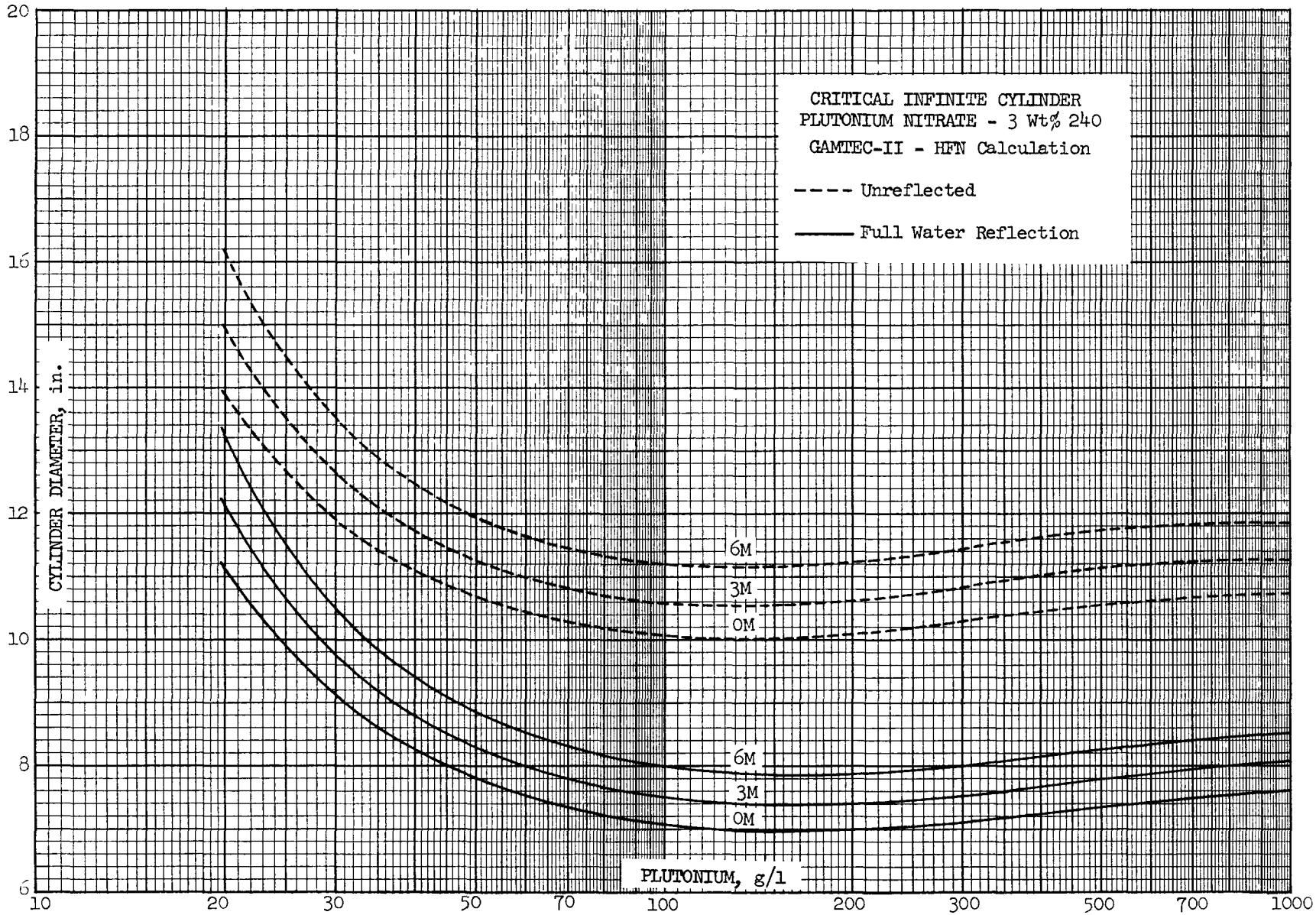

CRITICAL INFINITE CYLINDER
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
CYLINDER DIAMETER, in.
PLUTONIUM, g/l
Unreflected
1" H2O Reflector
Full H2O Reflector
22
20
18
16
14
12
10
8
10
20
30
50
70
100
200
300
500
700
1000

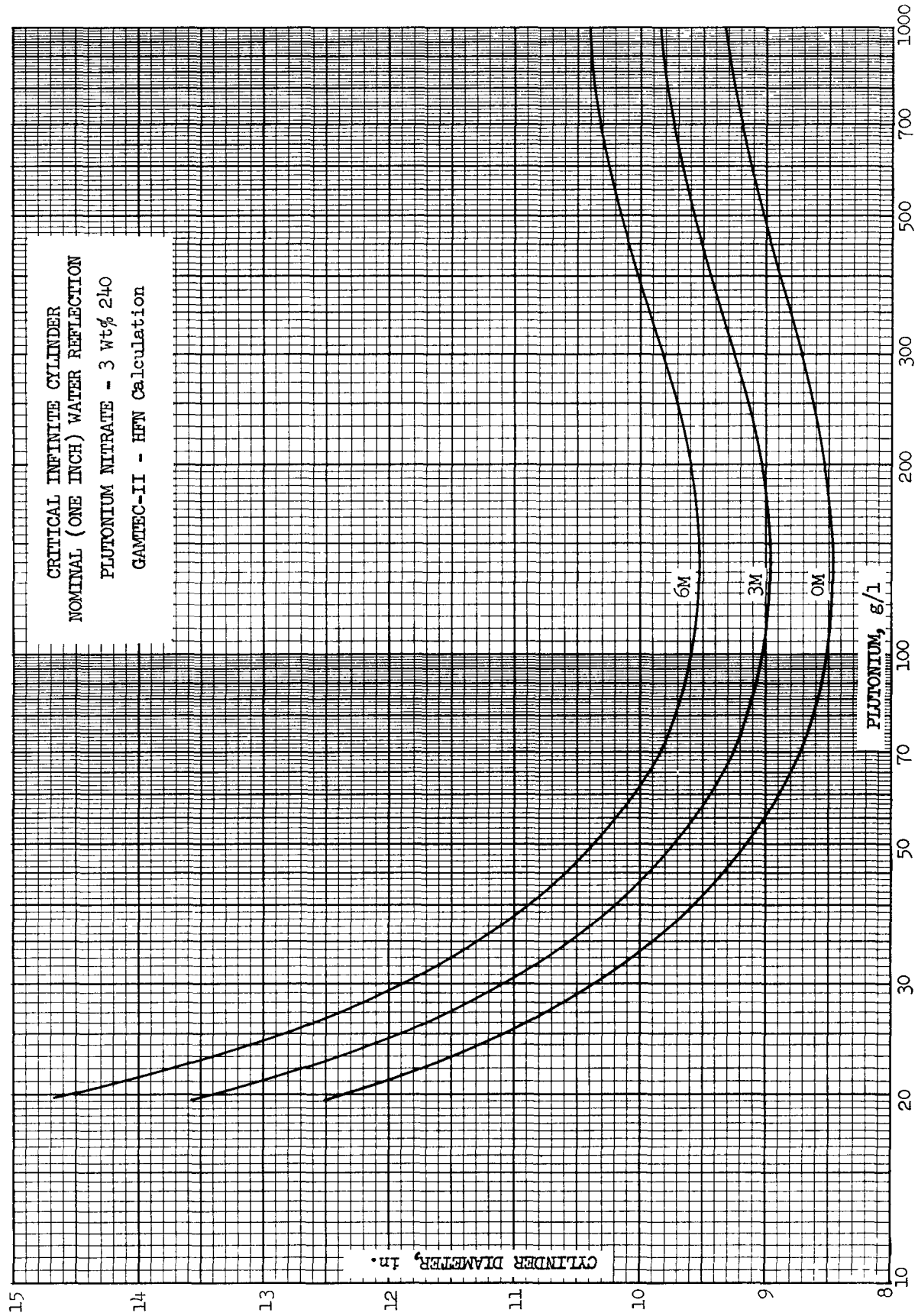

CRITICAL INFINITE CYLINDER
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
CYLINDER DIAMETER, in.
20
18
16
14
12
10
8
6
Unreflected
1" H2O Reflector
Full H2O Reflector
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

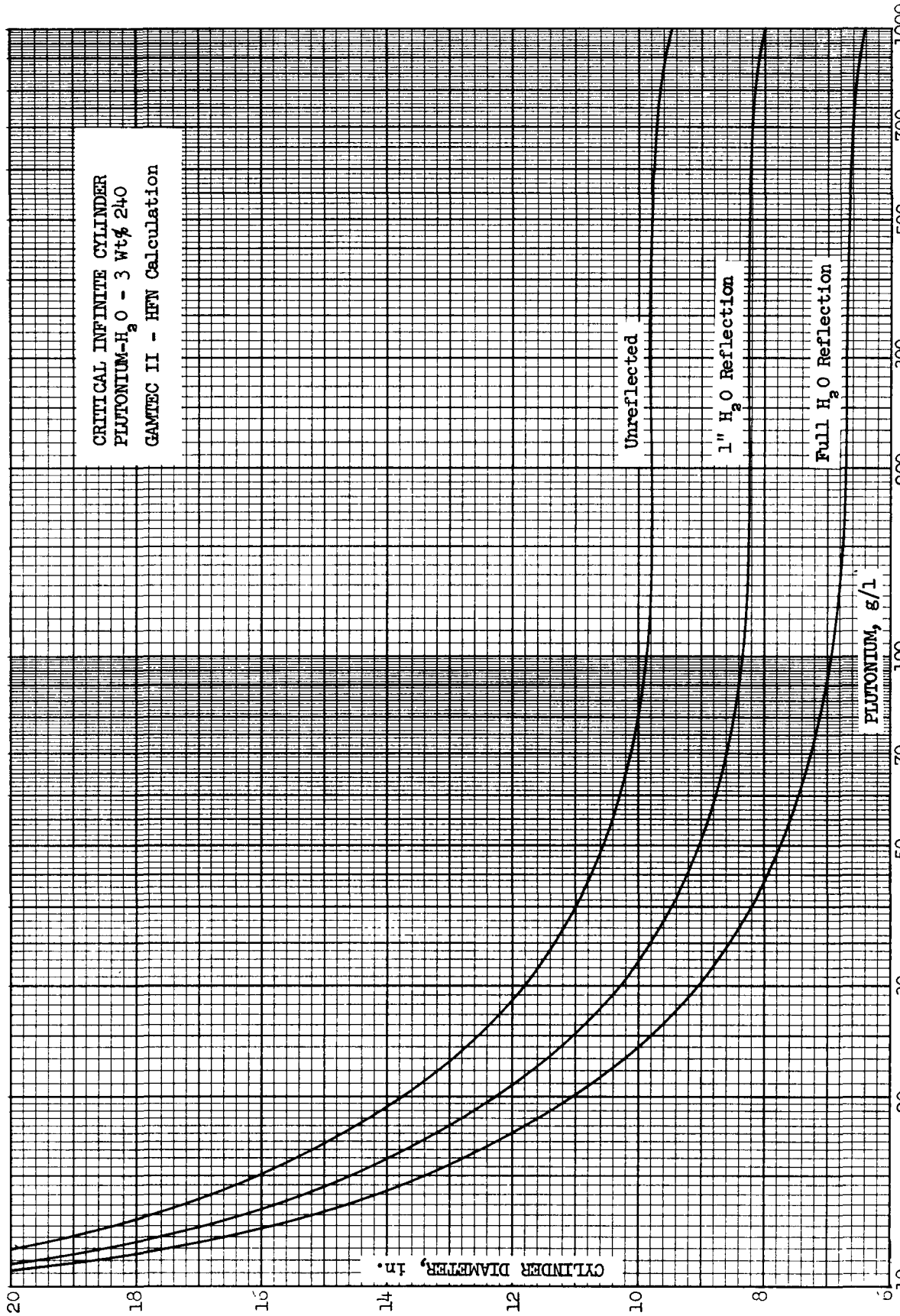

CRITICAL INFINITE CYLINDER
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculations
--- Unreflected
—— Full Water Reflection
CYLINDER DIAMETER, in.
PLUTONIUM, g/l
6M
3M
0M
6M
3M
0M
20
18
16
14
12
10
8
6
10
20
30
50
70
100
200
300
500
700
1000

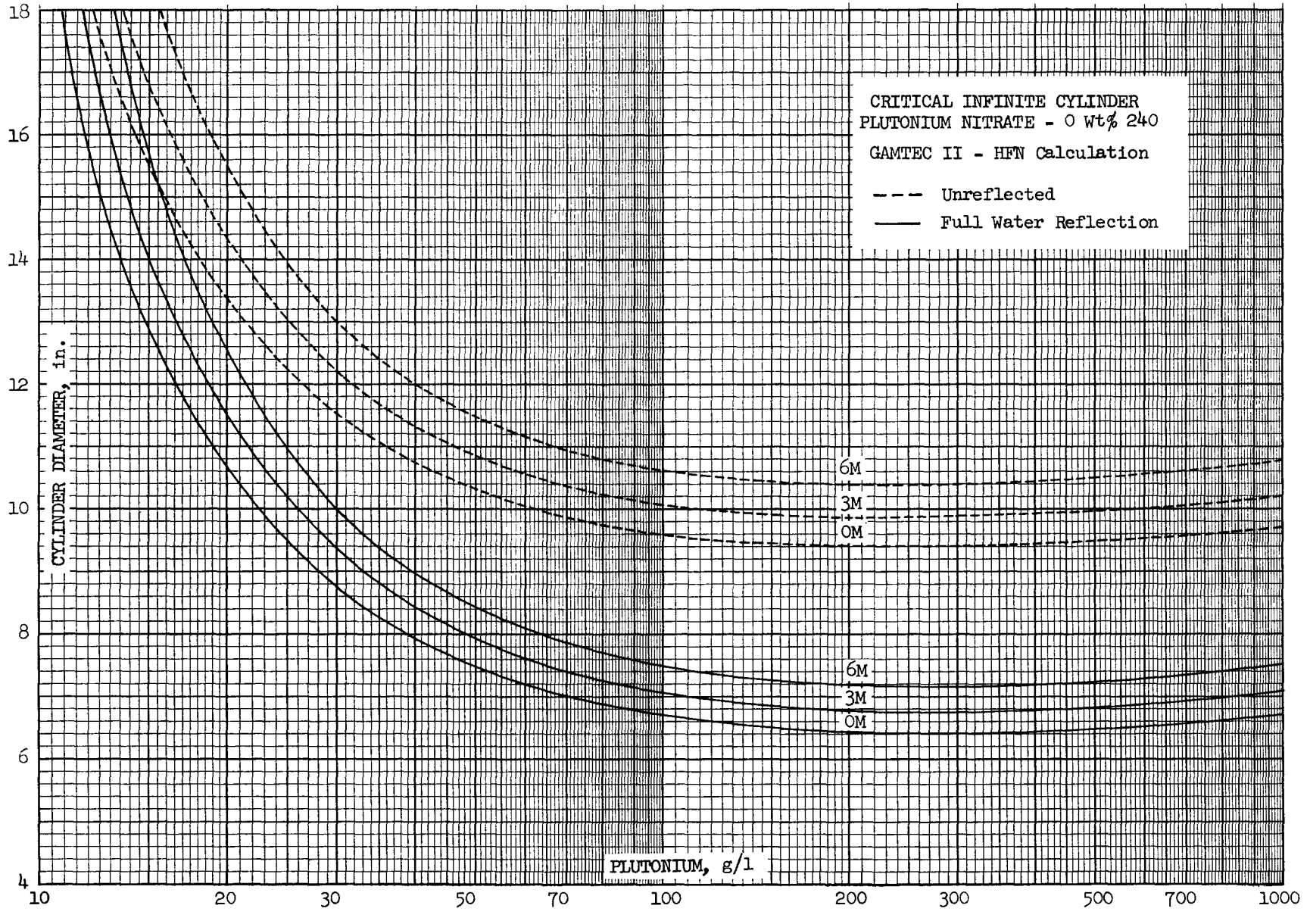

CRITICAL INFINITE CYLINDER
NOMINAL (ONE INCH) WATER REFLECTOR
PLUTONIUM NITRATE - 5 wt% 240
GAMTEC II - HFN Calculation
6M
3M
0M
PLUTONIUM, g/l
CYLINDER DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
8
22
20
18
16
14
12
10

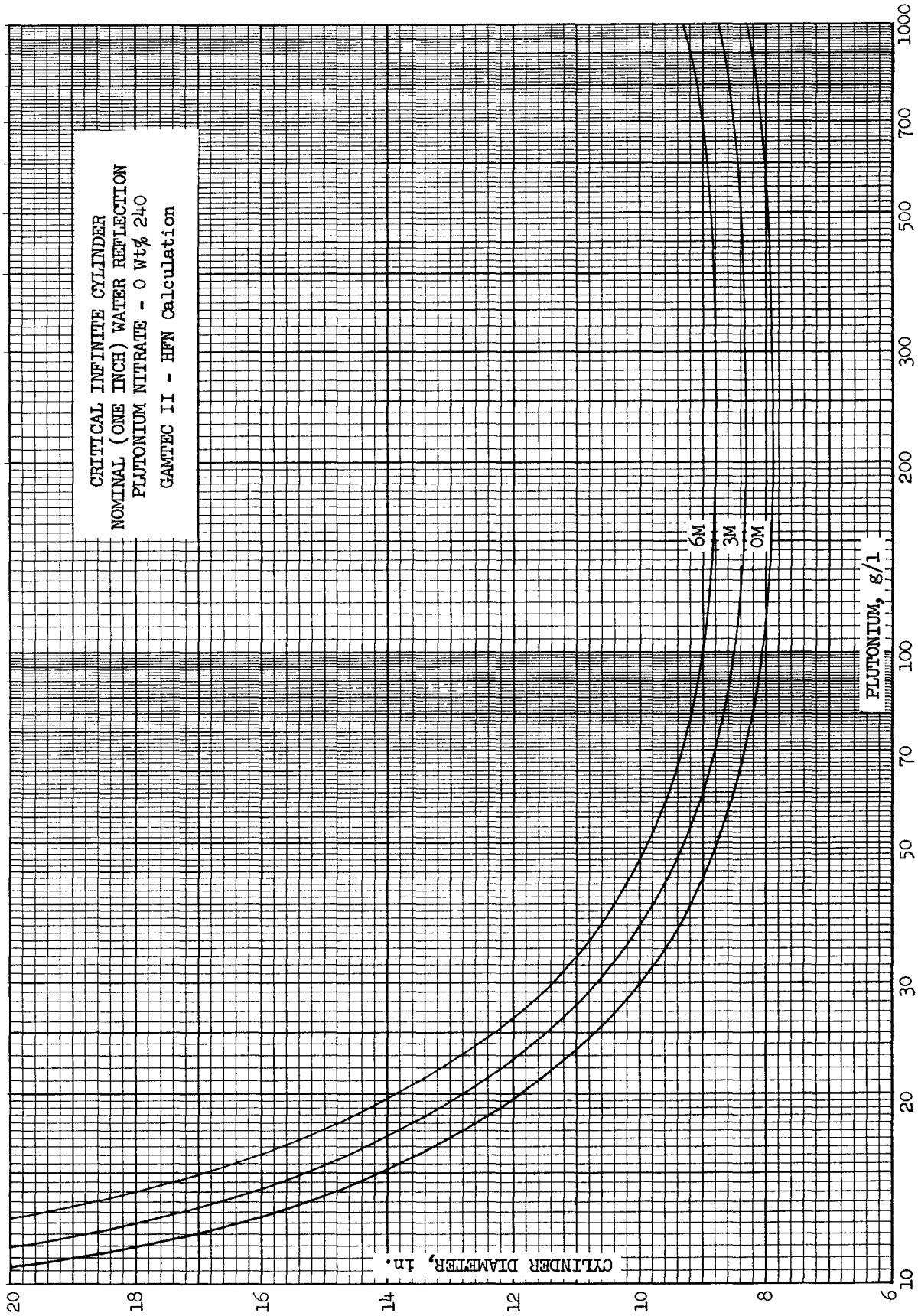

CRITICAL INFINITE CYLINDER
PLUTONIUM-H_2O - 5 Wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
PLUTONIUM, g/l
CYLINDER DIAMETER, in.
20
18
16
14
12
10
8
6
10
20
30
50
70
100
200
300
500
700
1000

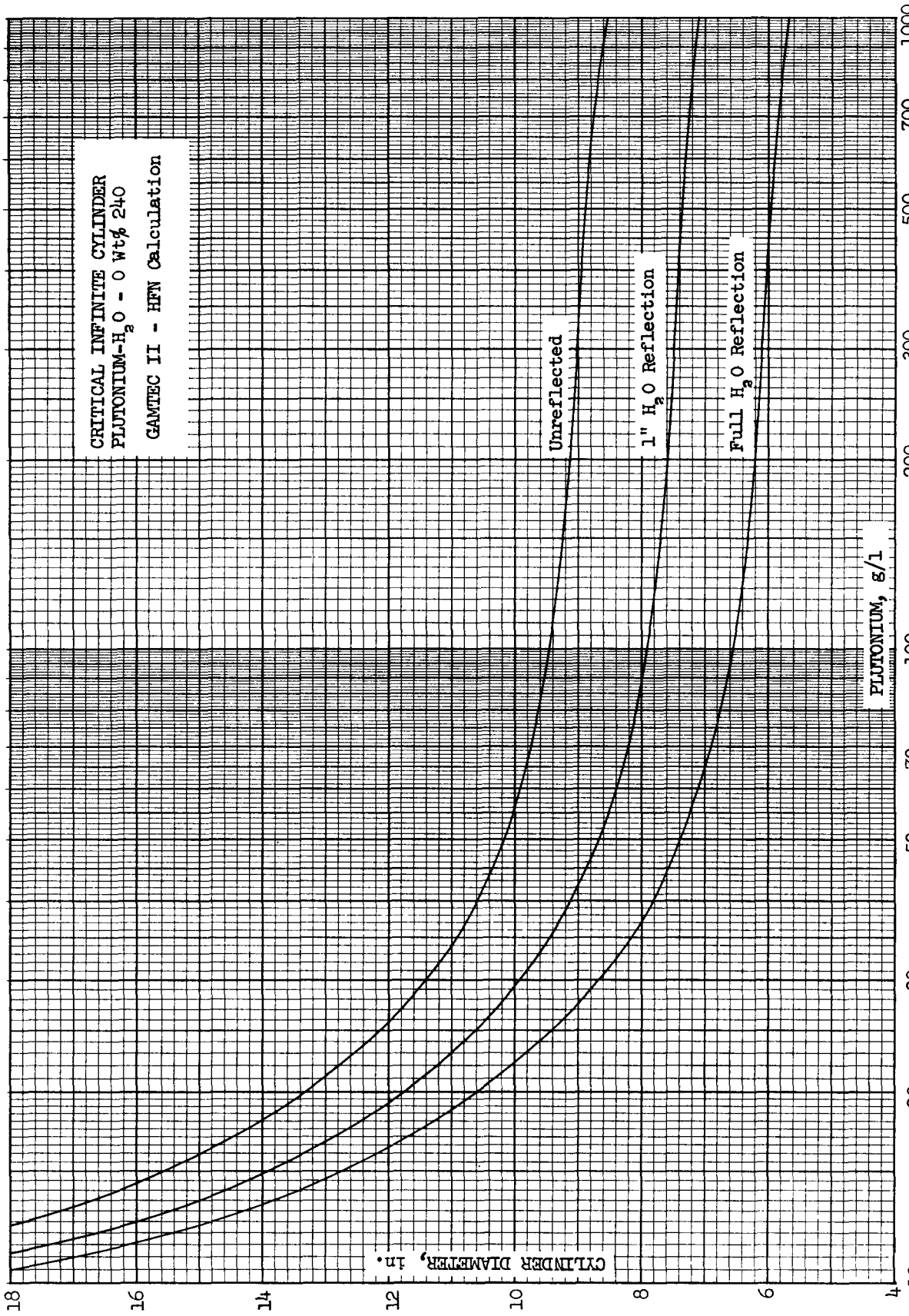

CRITICAL INFINITE CYLINDER
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-II - HFN Calculation
---- Unreflected
——— Full Water Reflection
CYLINDER DIAMETER, in.
PLUTONIUM, g/l
20
18
16
14
12
10
8
6
10
20
30
50
70
100
200
300
500
700
1000
6M
3M
0M
6M
3M
0M

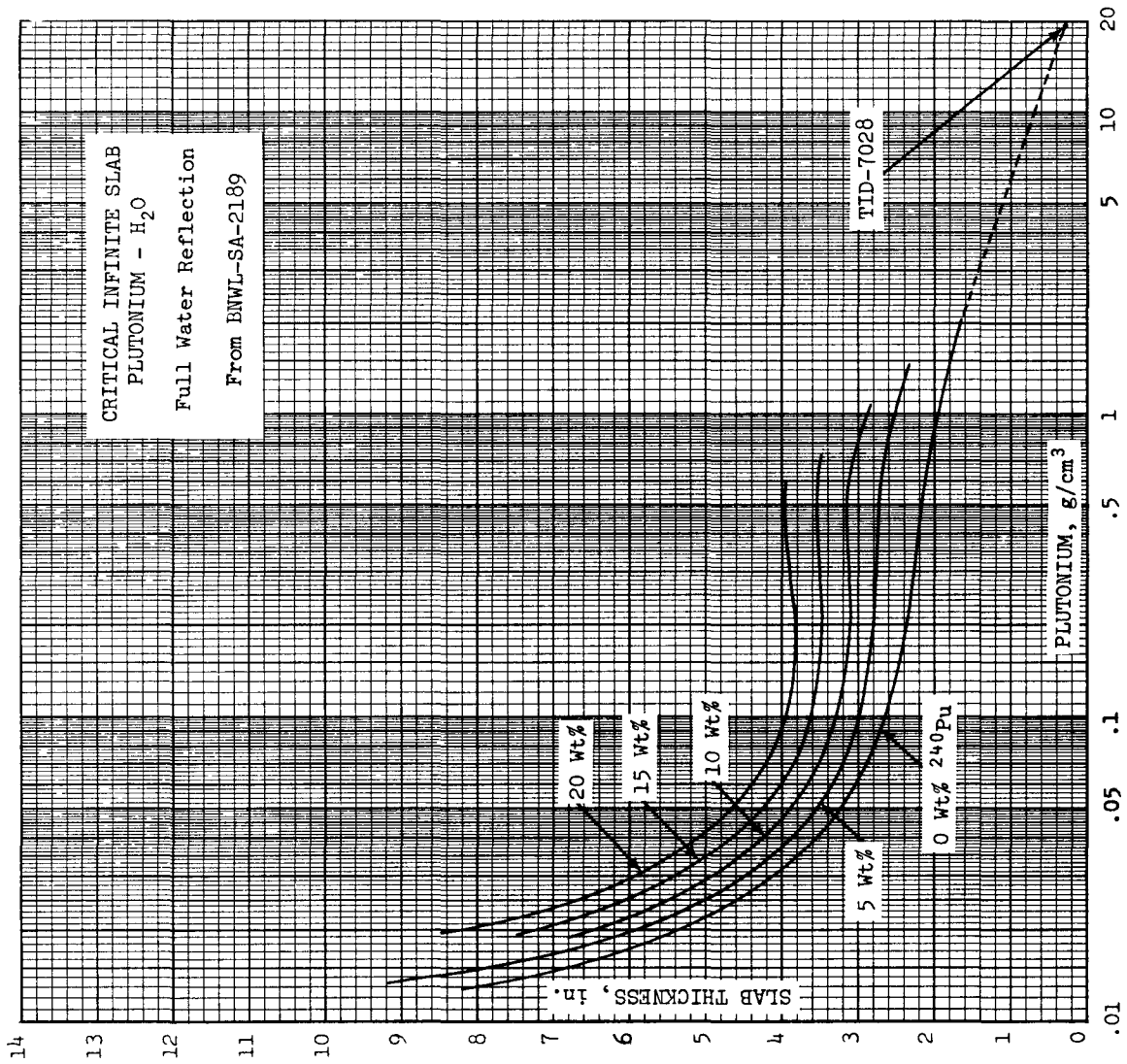

CRITICAL INFINITE CYLINDER
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-II - HFN Calculation
6M
3M
0M
PLUTONIUM, g/l
CYLINDER DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
15
14
13
12
11
10
9
8

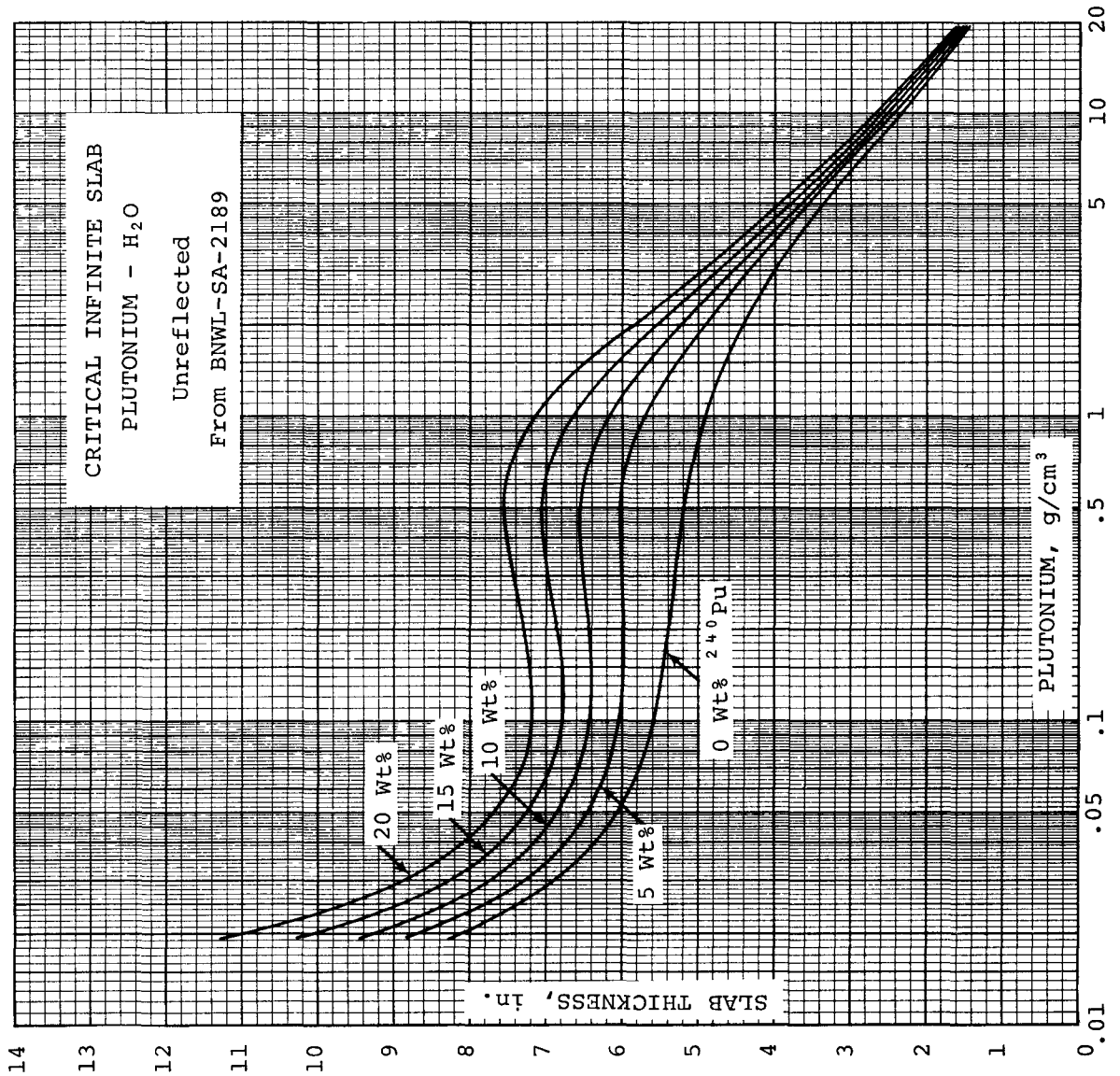

CRITICAL INFINITE CYLINDER
PLUTONIUM-H_2O - 3 Wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
PLUTONIUM, g/l
CYLINDER DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
20
18
16
14
12
10
8

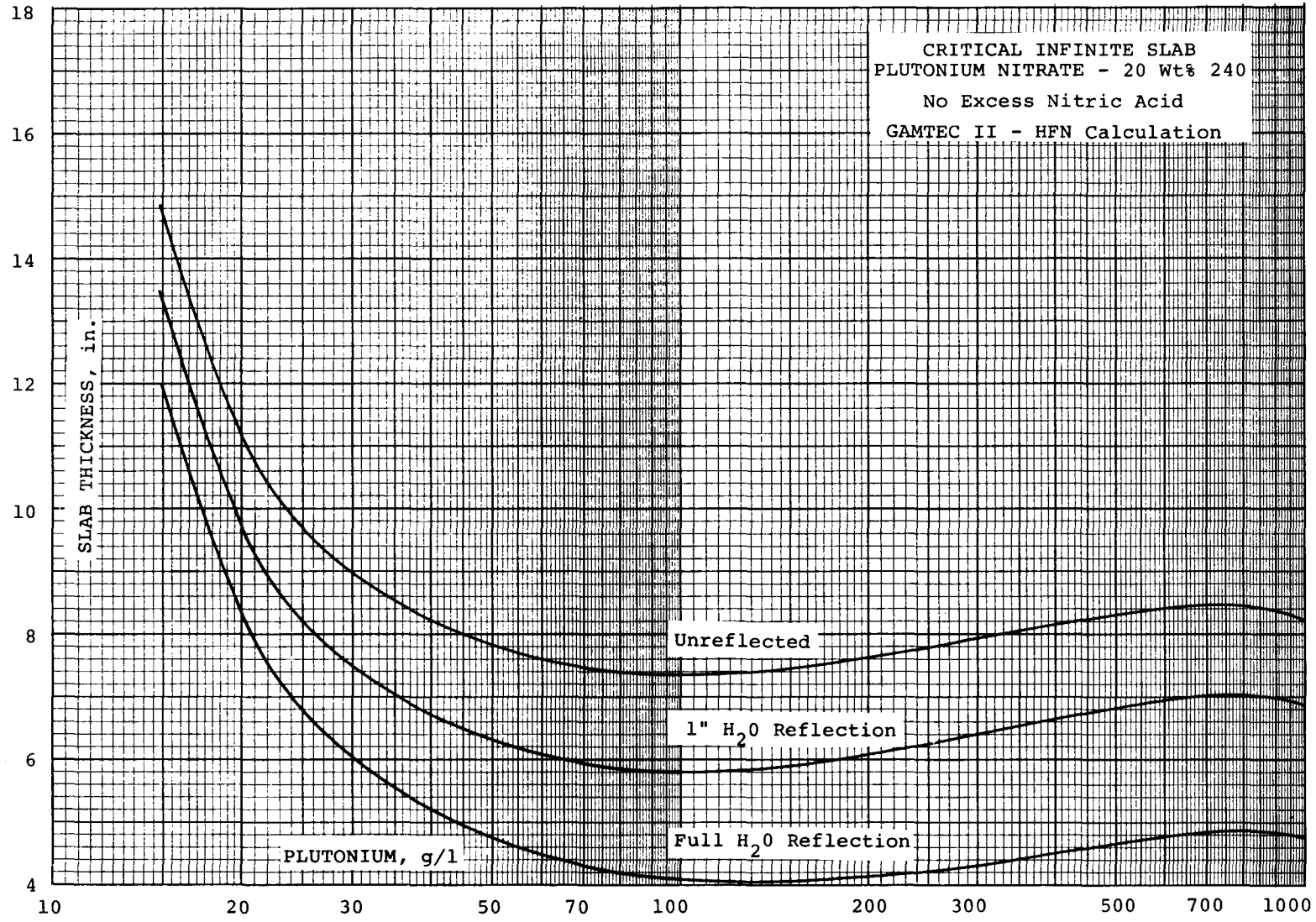

CRITICAL INFINITE CYLINDER
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Calculation
Unreflected
Full Water Reflection
CYLINDER DIAMETER, in.
PLUTONIUM, g/l
6M
3M
0M
6M
3M
0M
18
16
14
12
10
8
6
4
10
20
30
50
70
100
200
300
500
700
1000

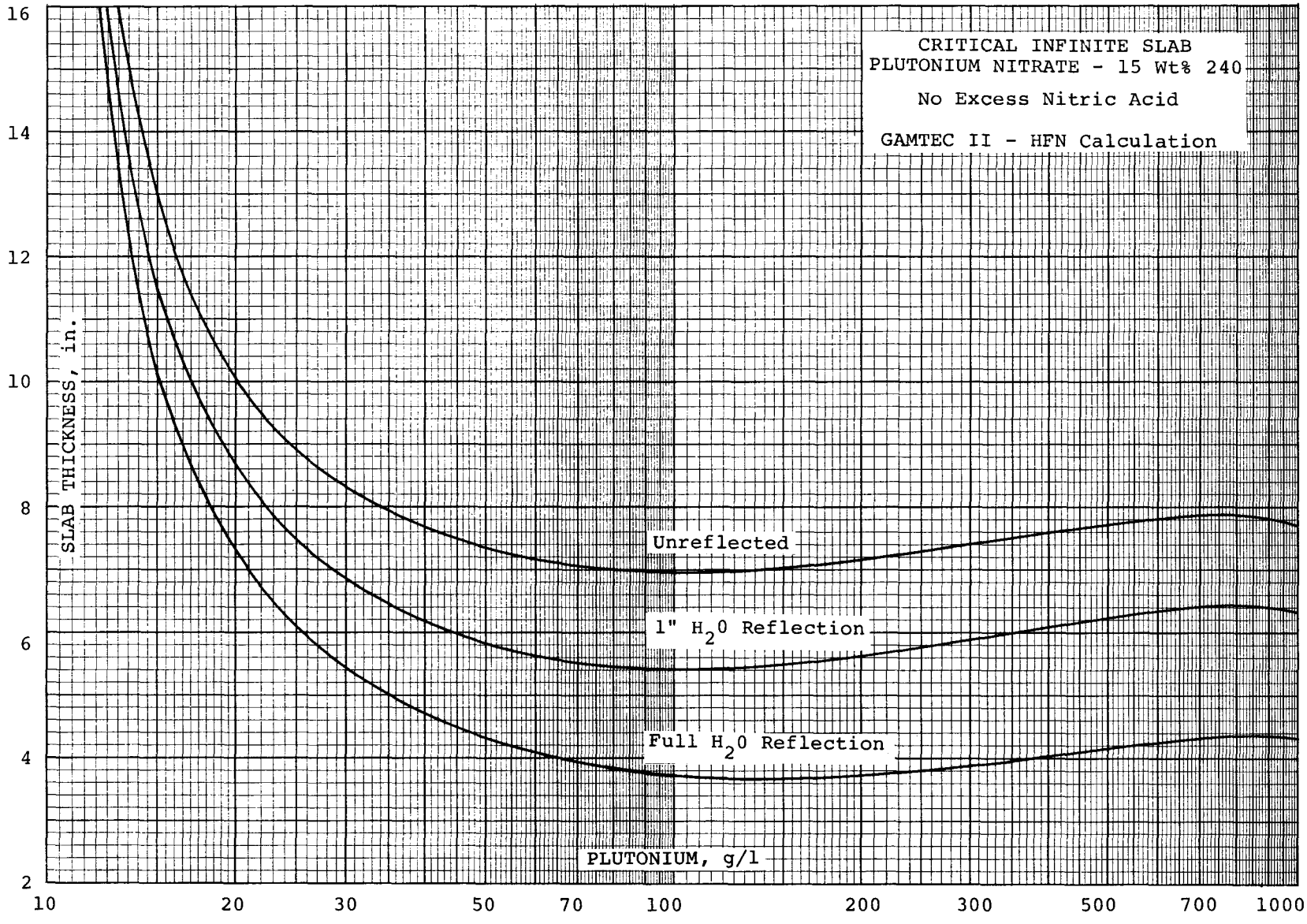

CRITICAL INFINITE CYLINDER
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 0 wt% 240
GAMTEC II - HFN Calculation
6M
3M
0M
PLUTONIUM, g/l
CYLINDER DIAMETER, in.
20
18
16
14
12
10
8
6
1000
700
500
300
200
100
70
50
30
20
10

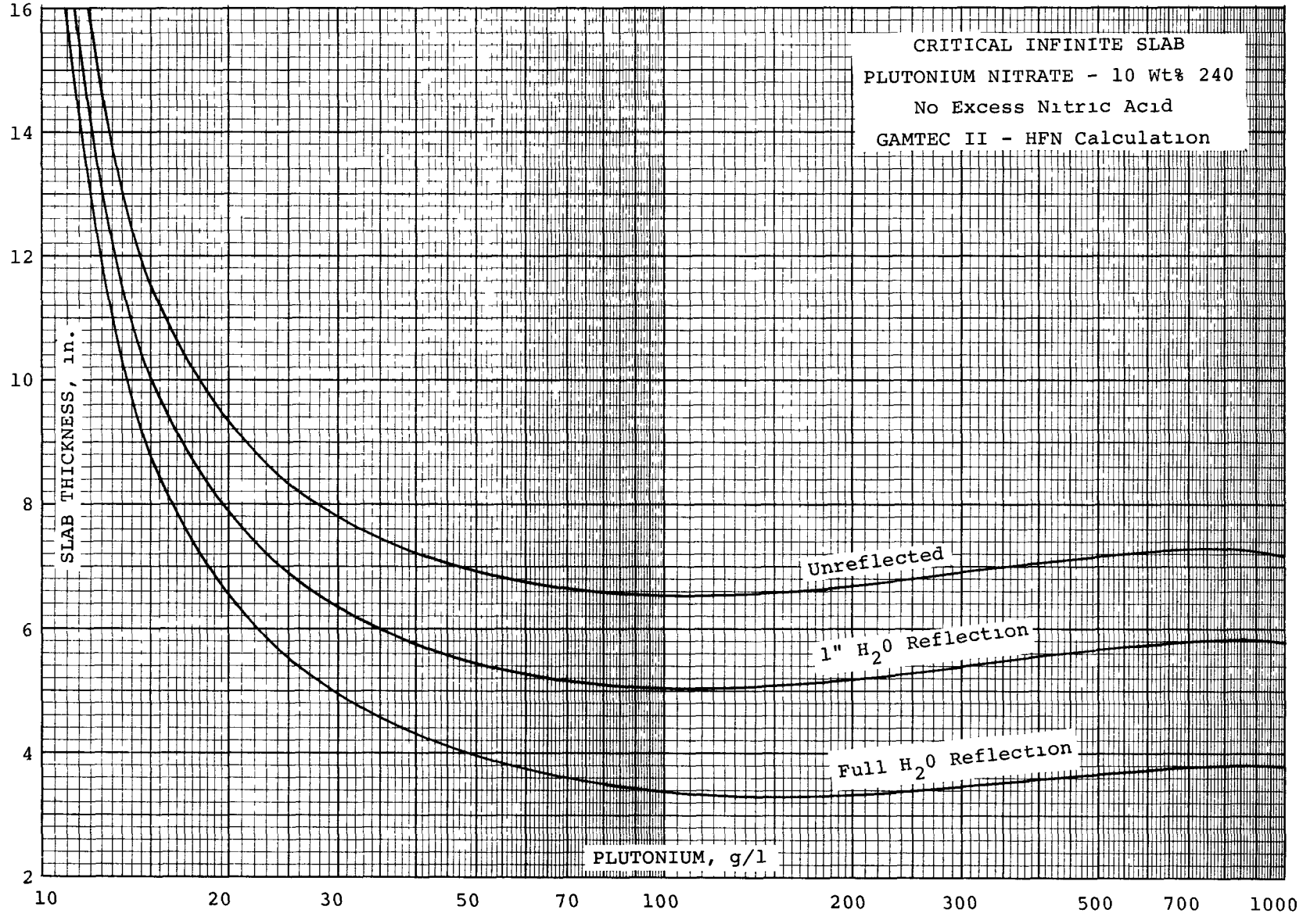

CRITICAL INFINITE CYLINDER
PLUTONIUM-H_2O - 0 wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
PLUTONIUM, g/l
CYLINDER DIAMETER, in.
1000
700
500
300
200
100
70
50
30
20
10
18
16
14
12
10
8
6
4

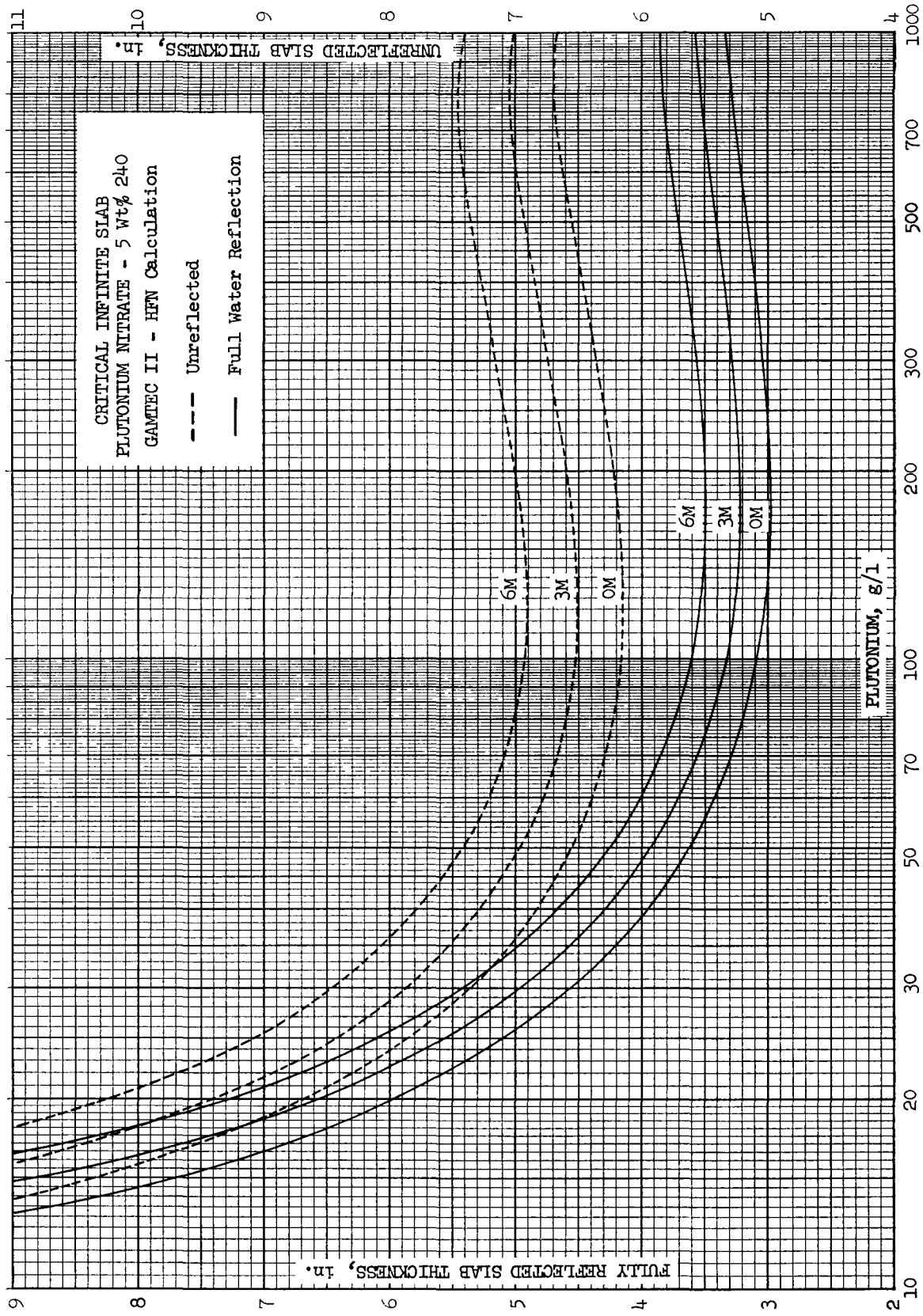

CRITICAL INFINITE SLAB
PLUTONIUM - H_2O
Full Water Reflection
From BNWL-SA-2189
TID-7028
20 Wt%
15 Wt%
10 Wt%
5 Wt%
0 Wt% 240Pu
SLAB THICKNESS, in.
PLUTONIUM, g/cm3
.01
.05
.1
.5
1
5
10
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

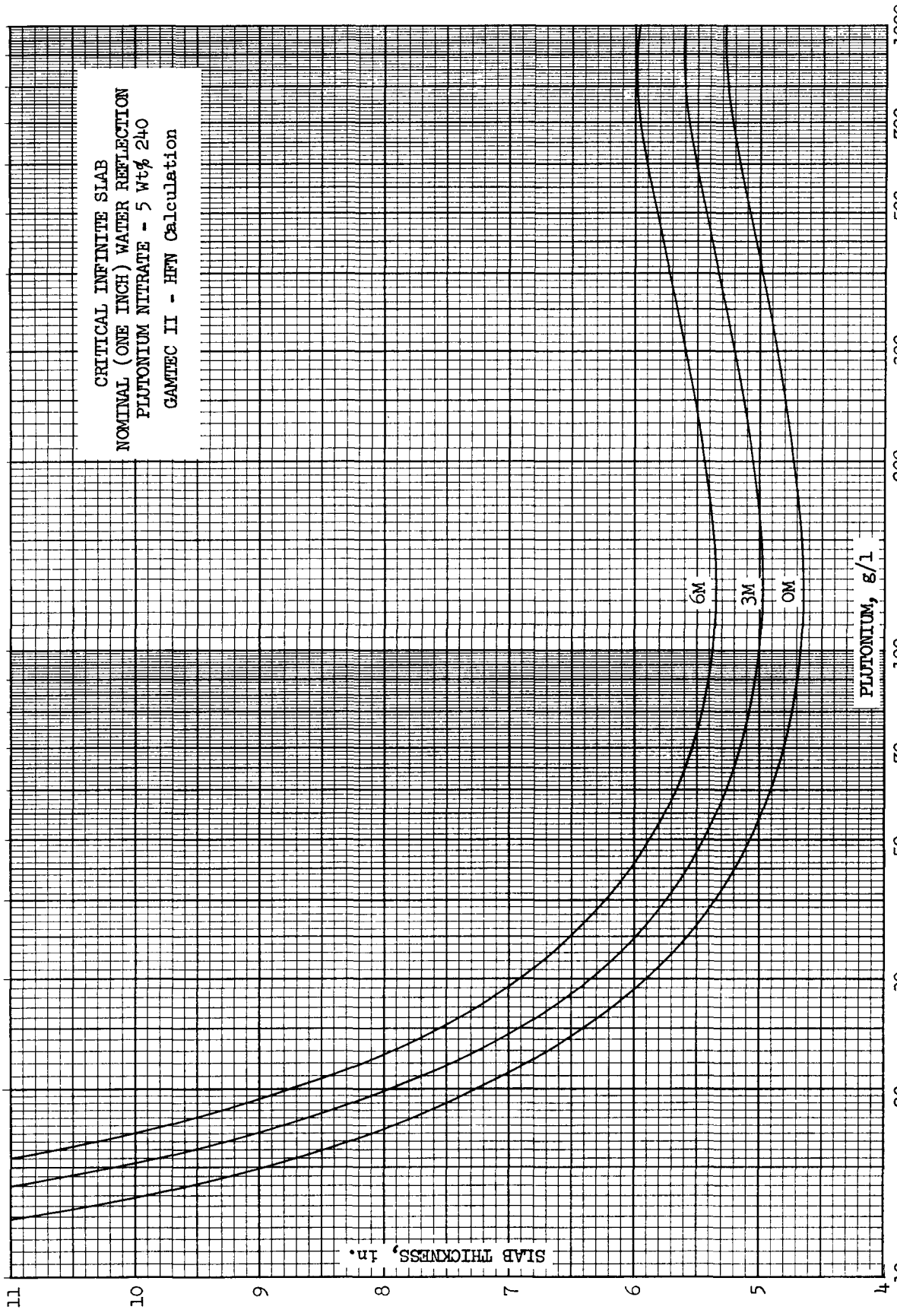

CRITICAL INFINITE SLAB
PLUTONIUM - H_2O
Unreflected
From BNWL-SA-2189
SLAB THICKNESS, in.
PLUTONIUM, g/cm³
0 Wt% ^{240}Pu
5 Wt%
10 Wt%
15 Wt%
20 Wt%
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
20 10 5 1 .5 .1 .05 .01

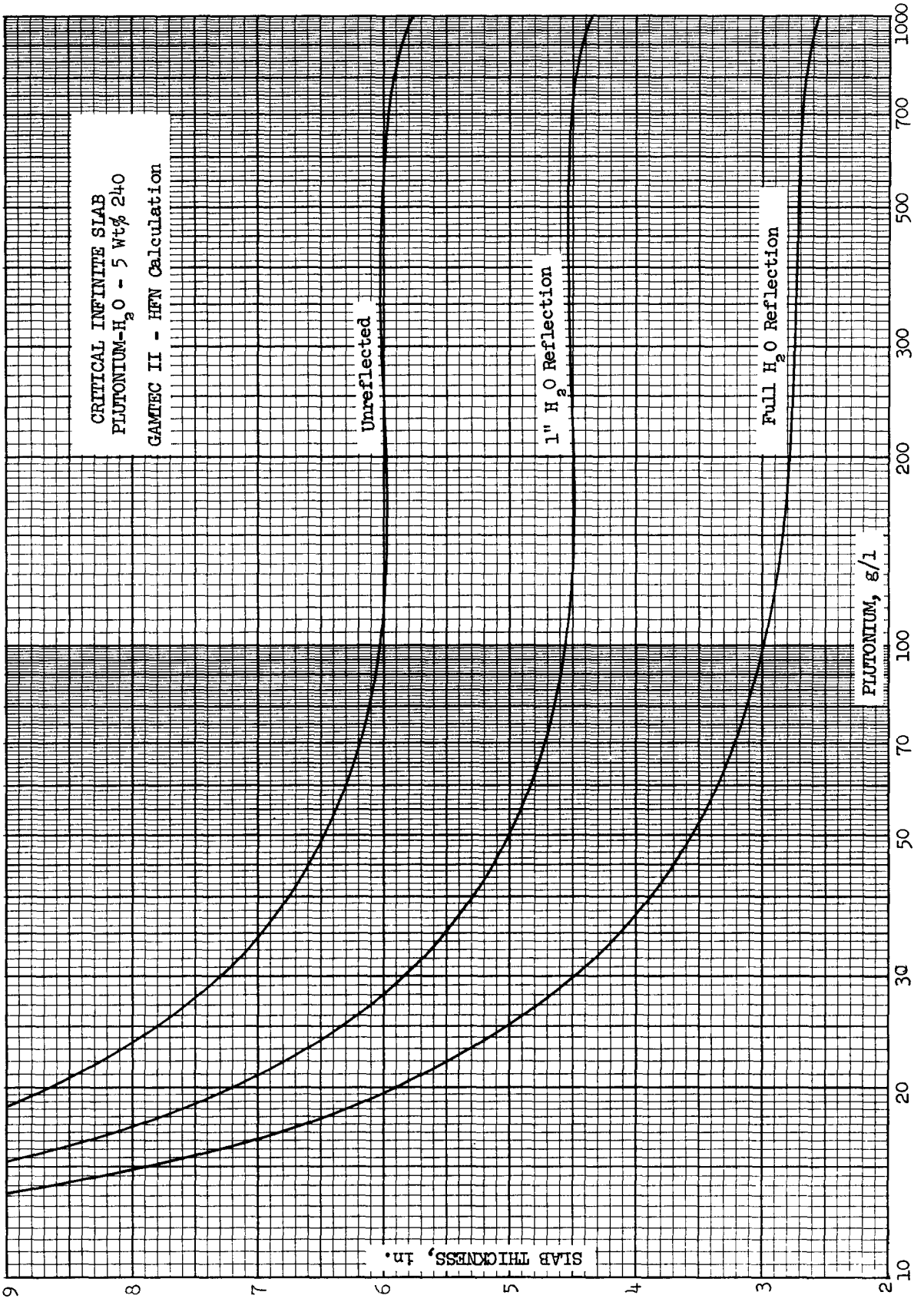

CRITICAL INFINITE SLAB
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
SLAB THICKNESS, in.
PLUTONIUM, g/l
Unreflected
1" H2O Reflection
Full H2O Reflection
18
16
14
12
10
8
6
4
10
20
30
50
70
100
200
300
500
700
1000

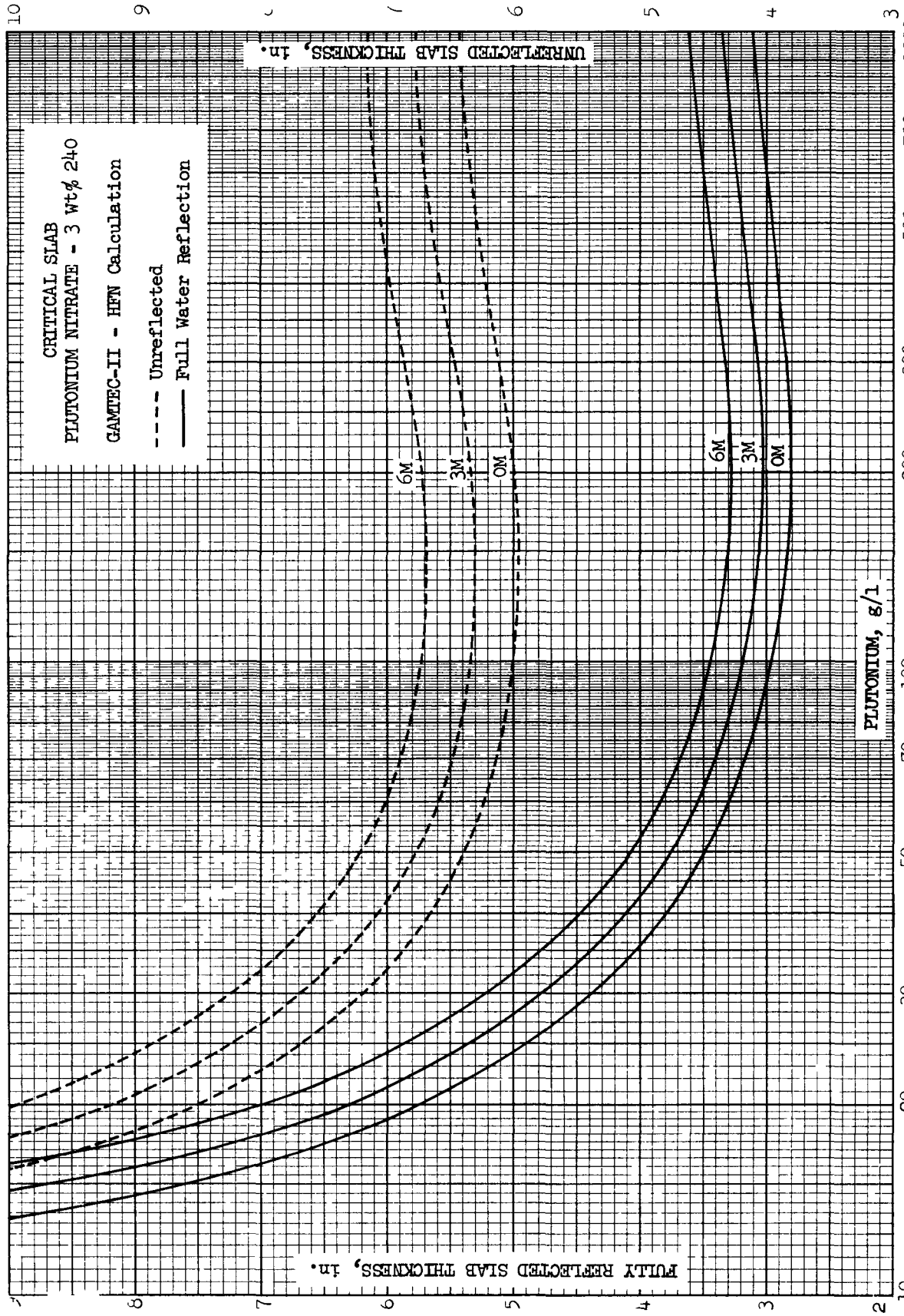

CRITICAL INFINITE SLAB
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
SLAB THICKNESS, in.
PLUTONIUM, g/l
Unreflected
1" H2O Reflection
Full H2O Reflection
16
14
12
10
8
6
4
2
10
20
30
50
70
100
200
300
500
700
1000

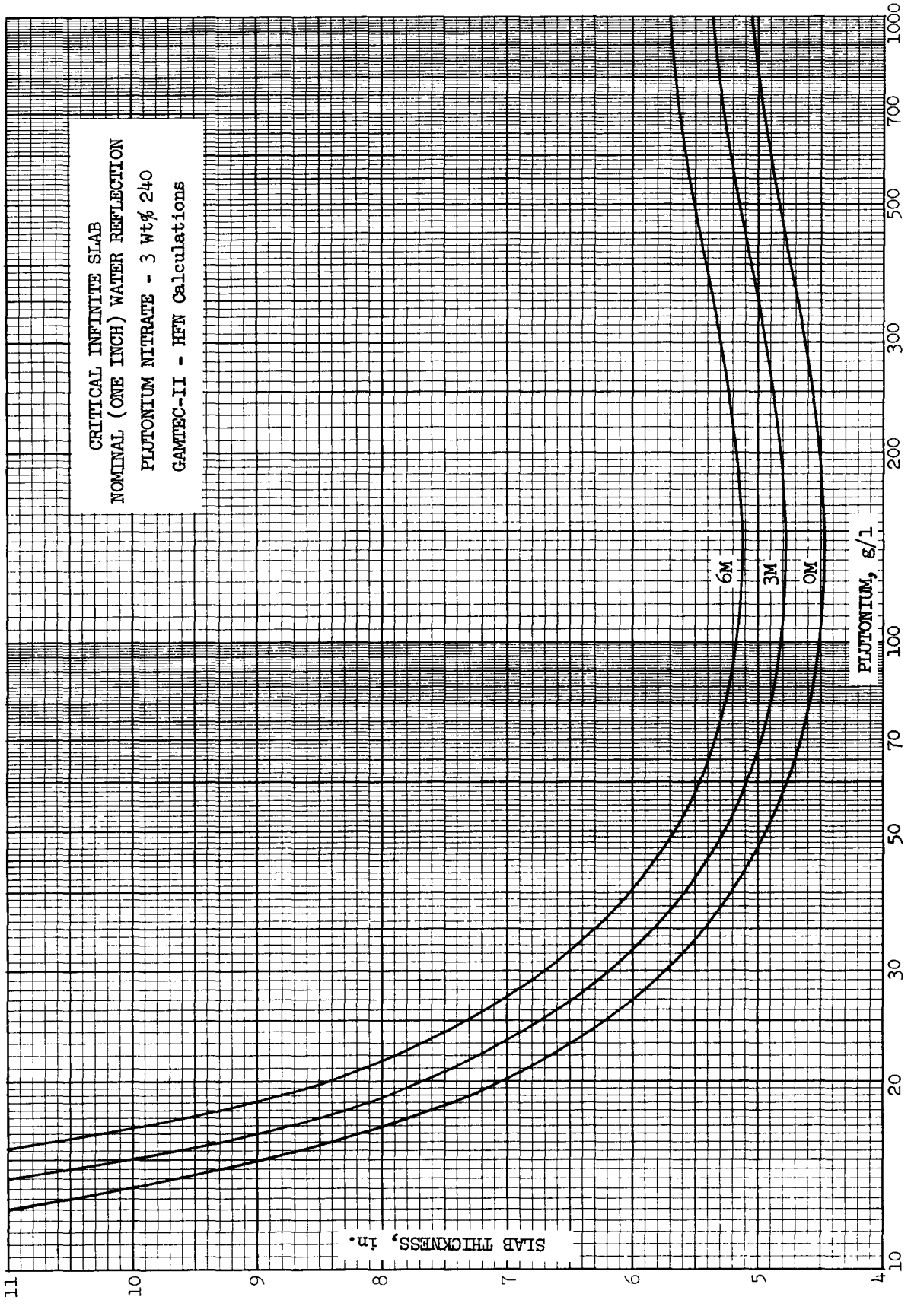

CRITICAL INFINITE SLAB
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
SLAB THICKNESS, in.
PLUTONIUM, g/l
Unreflected
1" H_2O Reflection
Full H_2O Reflection
16
14
12
10
8
6
4
2
10
20
30
50
70
100
200
300
500
700
1000

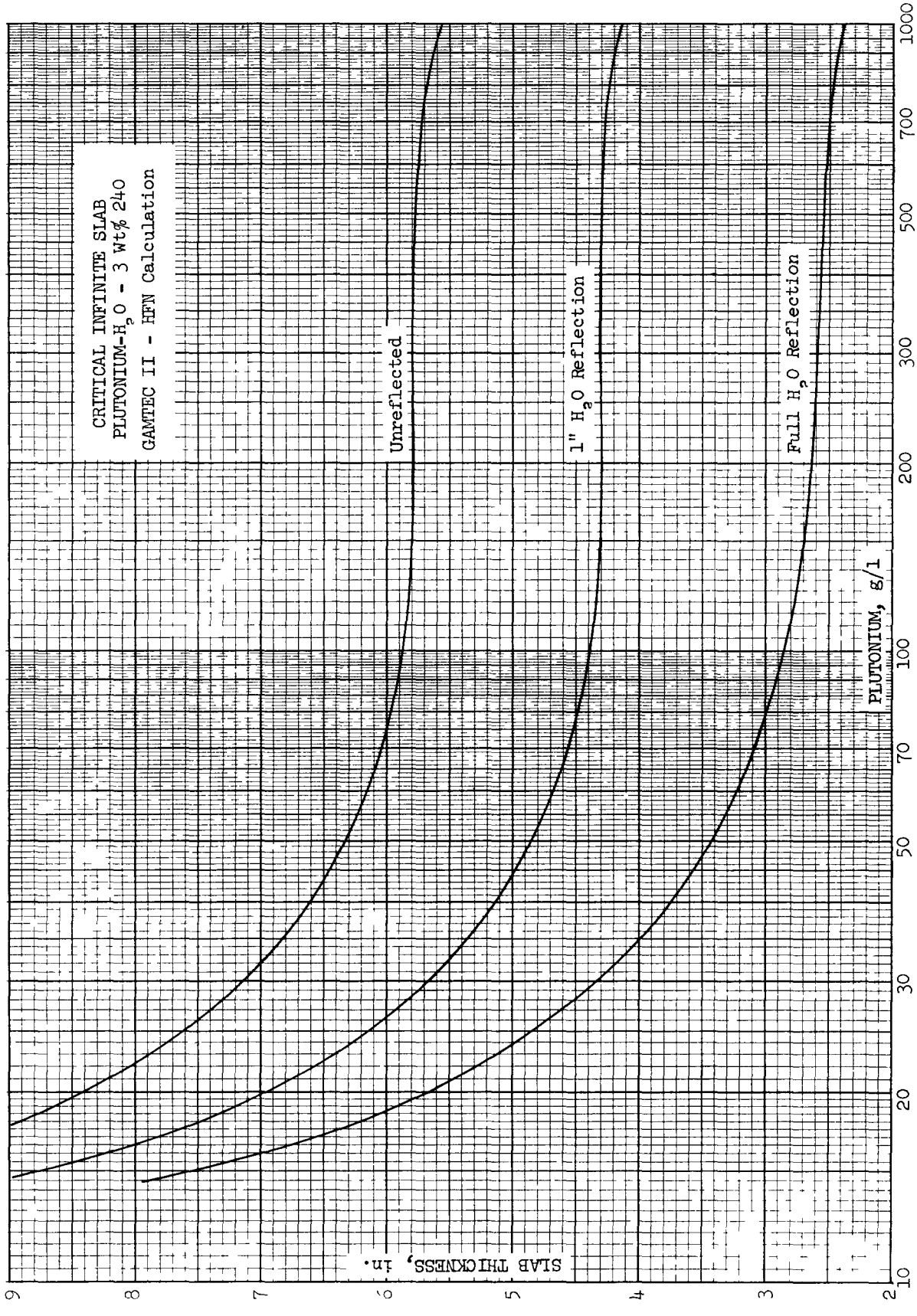

CRITICAL INFINITE SLAB
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculation
--- Unreflected
—— Full Water Reflection
UNREFLECTED SLAB THICKNESS, in.
FULLY REFLECTED SLAB THICKNESS, in.
PLUTONIUM, g/l
6M
3M
0M
6M
3M
0M

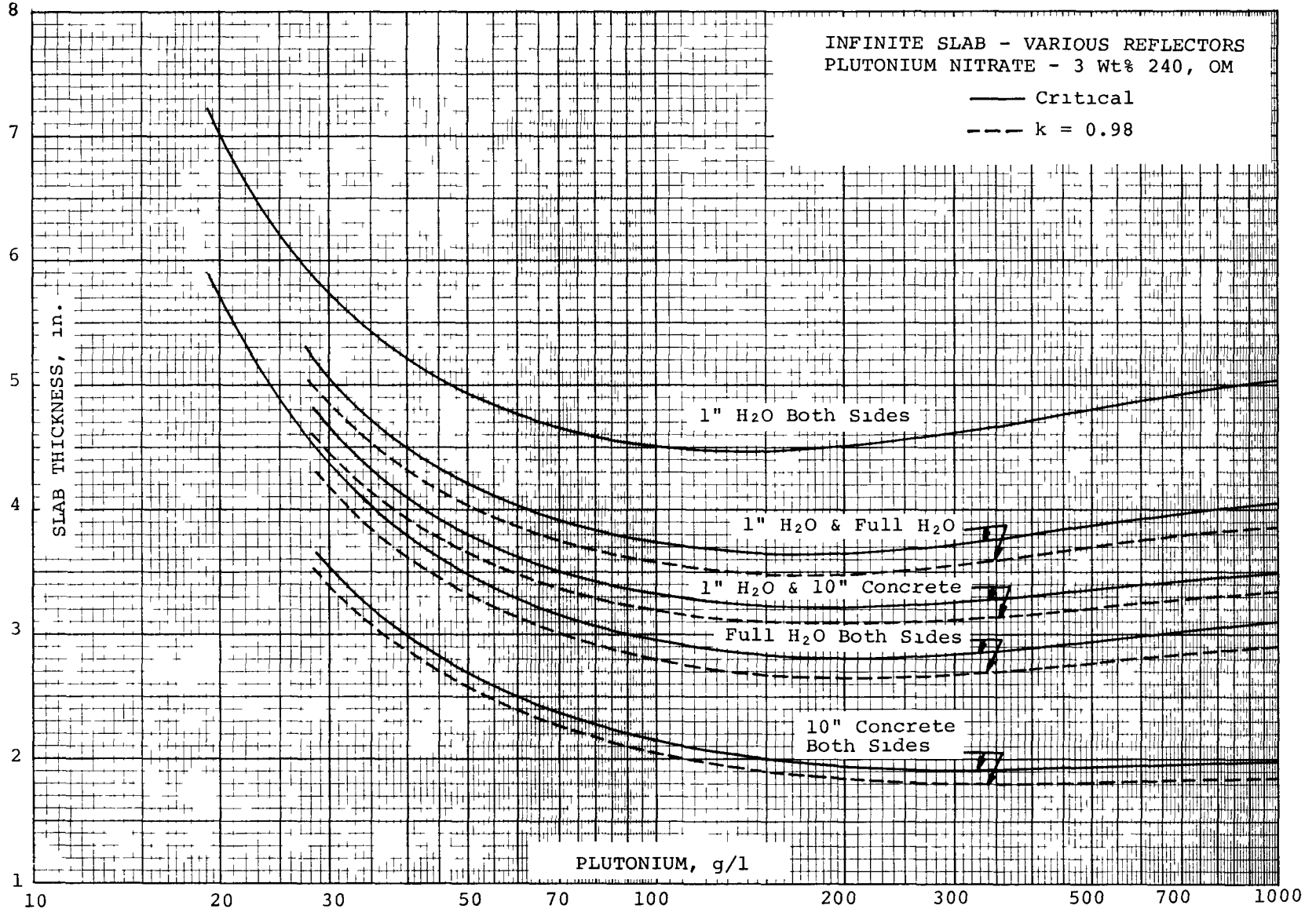

CRITICAL INFINITE SLAB
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculation
SLAB THICKNESS, in.
PLUTONIUM, g/l
6M
3M
0M
11
10
9
8
7
6
5
4
1000
700
500
300
200
100
70
50
30
20
10

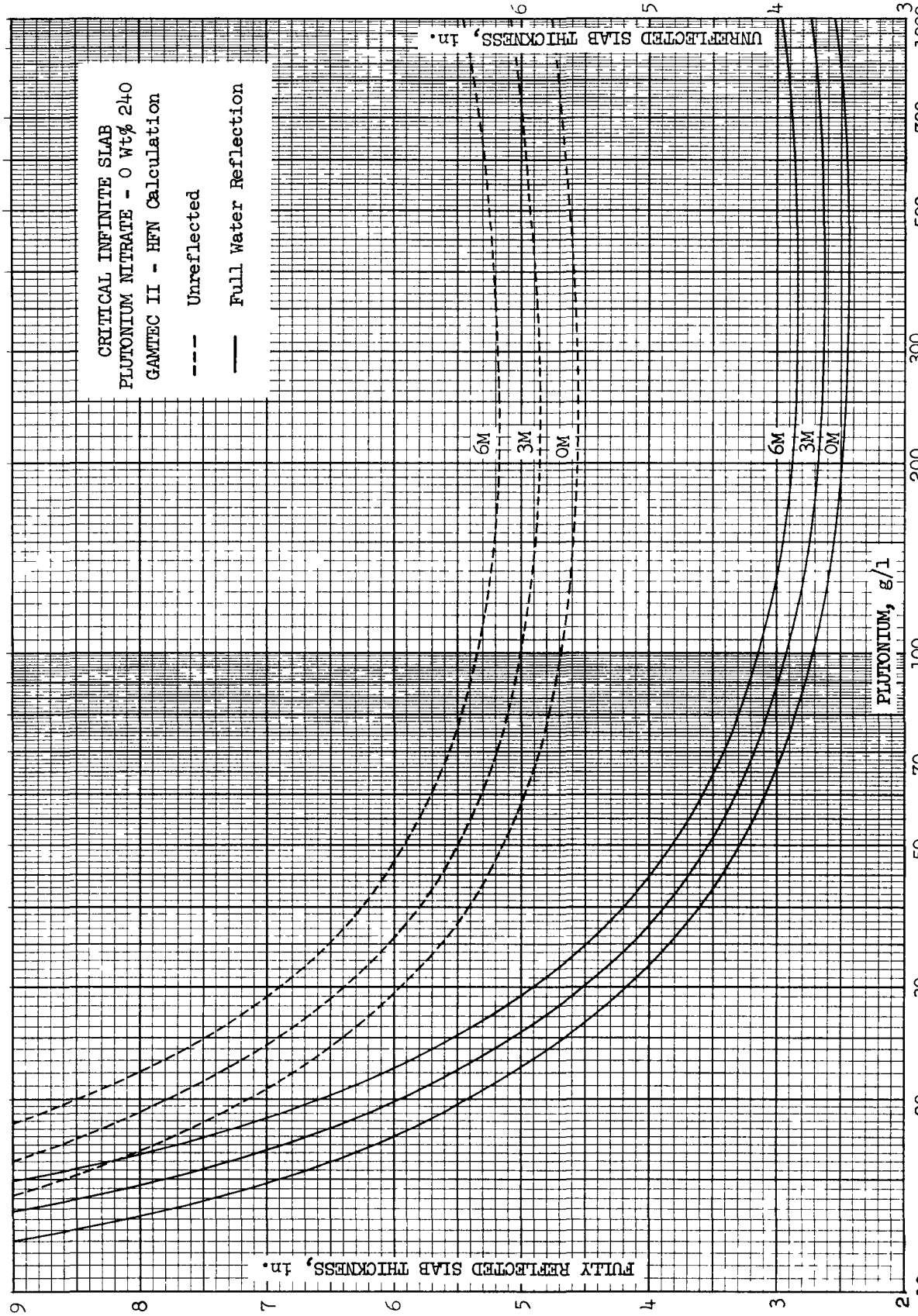

CRITICAL INFINITE SLAB
PLUTONIUM-H_2O - 5 wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
PLUTONIUM, g/l
SLAB THICKNESS, in.
1000
700
500
300
200
100
70
50
30
20
10
9
8
7
6
5
4
3
2

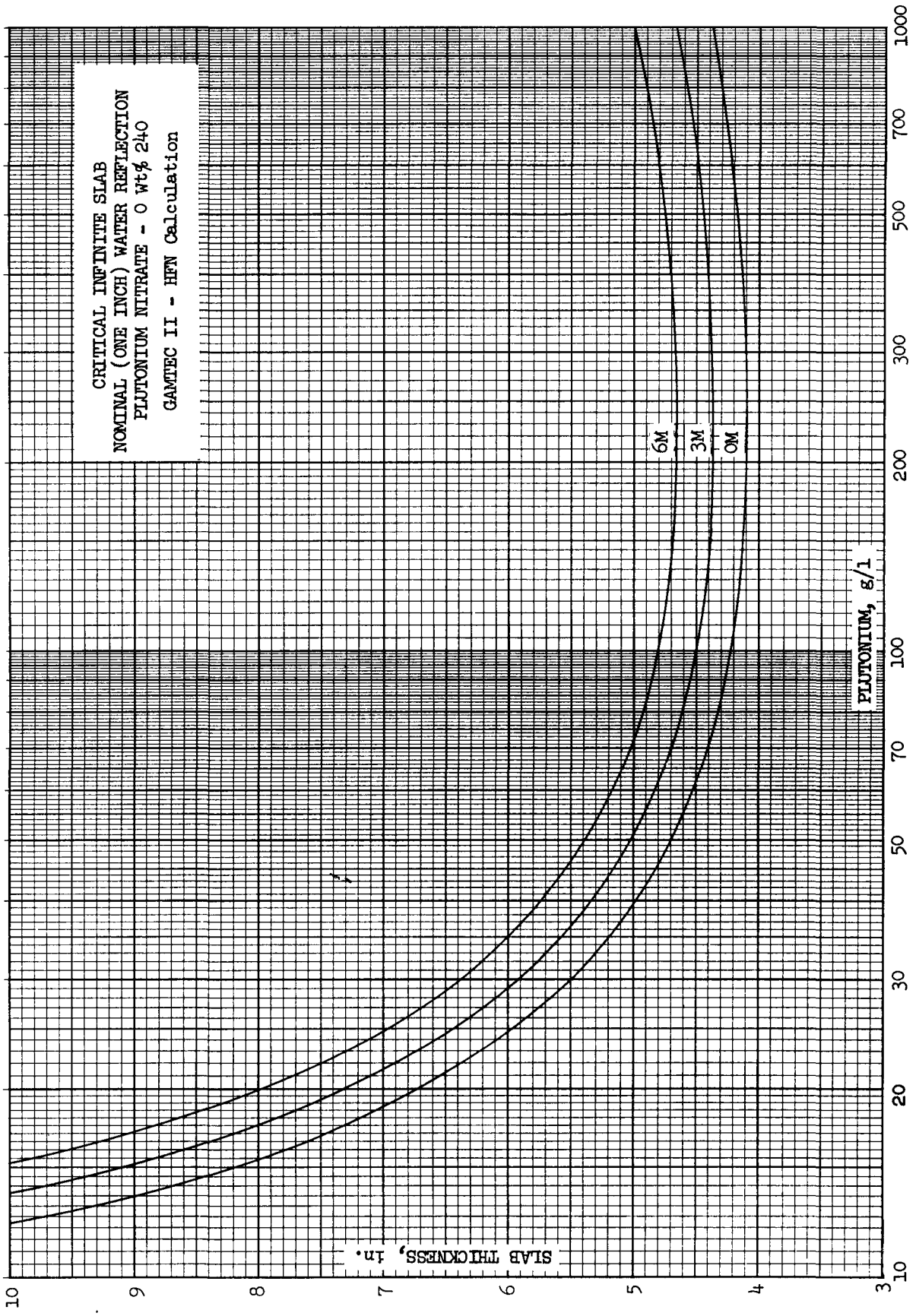

CRITICAL SLAB
PLUTONIUM NITRATE - 3 wt% 240
GAMTEC-II - HFN Calculation
---- Unreflected
—— Full Water Reflection
UNREFLECTED SLAB THICKNESS, in.
FULLY REFLECTED SLAB THICKNESS, in.
PLUTONIUM, g/l
6M
3M
0M

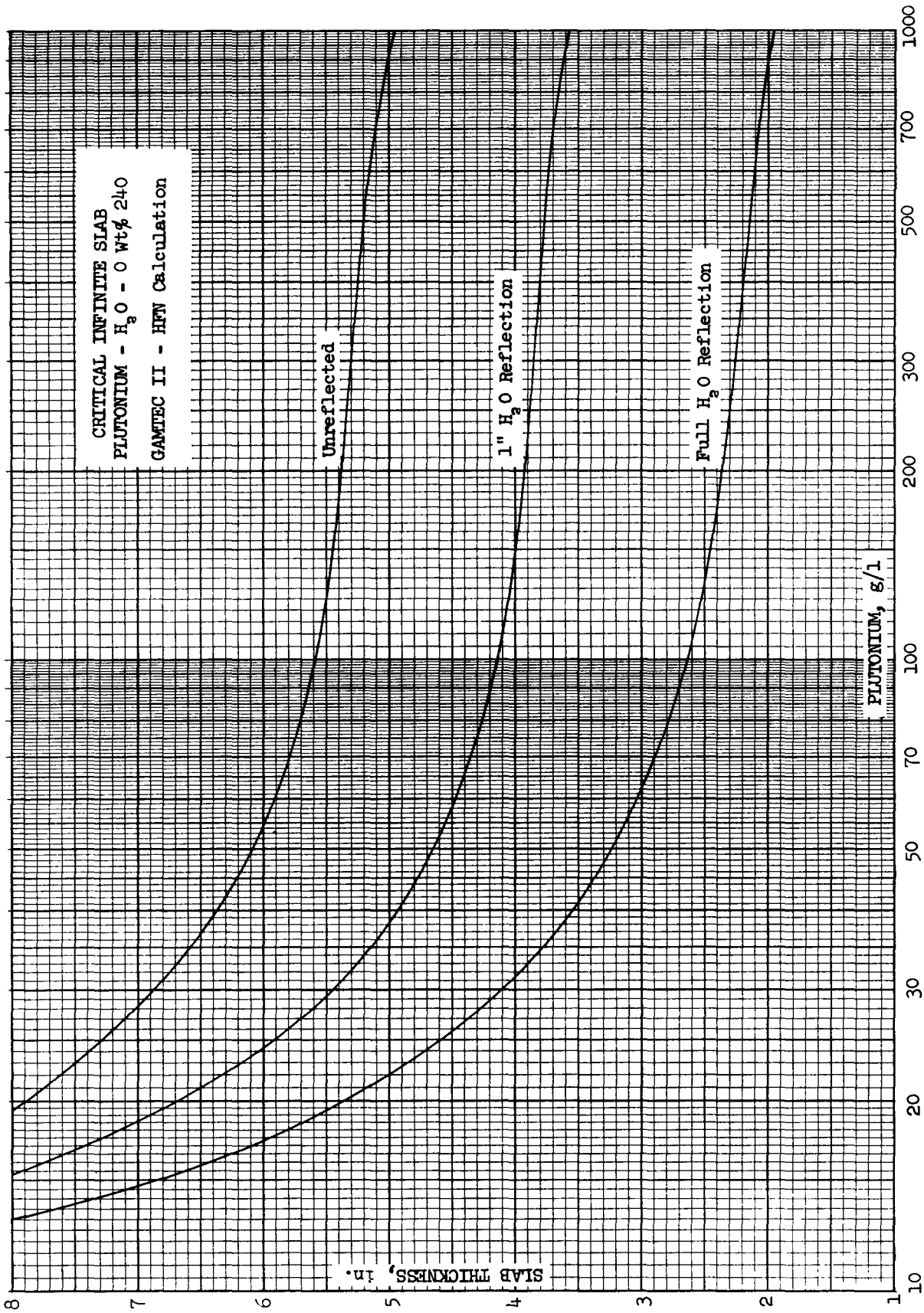

CRITICAL INFINITE SLAB
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-II - HFN Calculations
6M
3M
0M
PLUTONIUM, g/l
SLAB THICKNESS, in.
11
10
9
8
7
6
5
4
10
20
30
50
70
100
200
300
500
700
1000

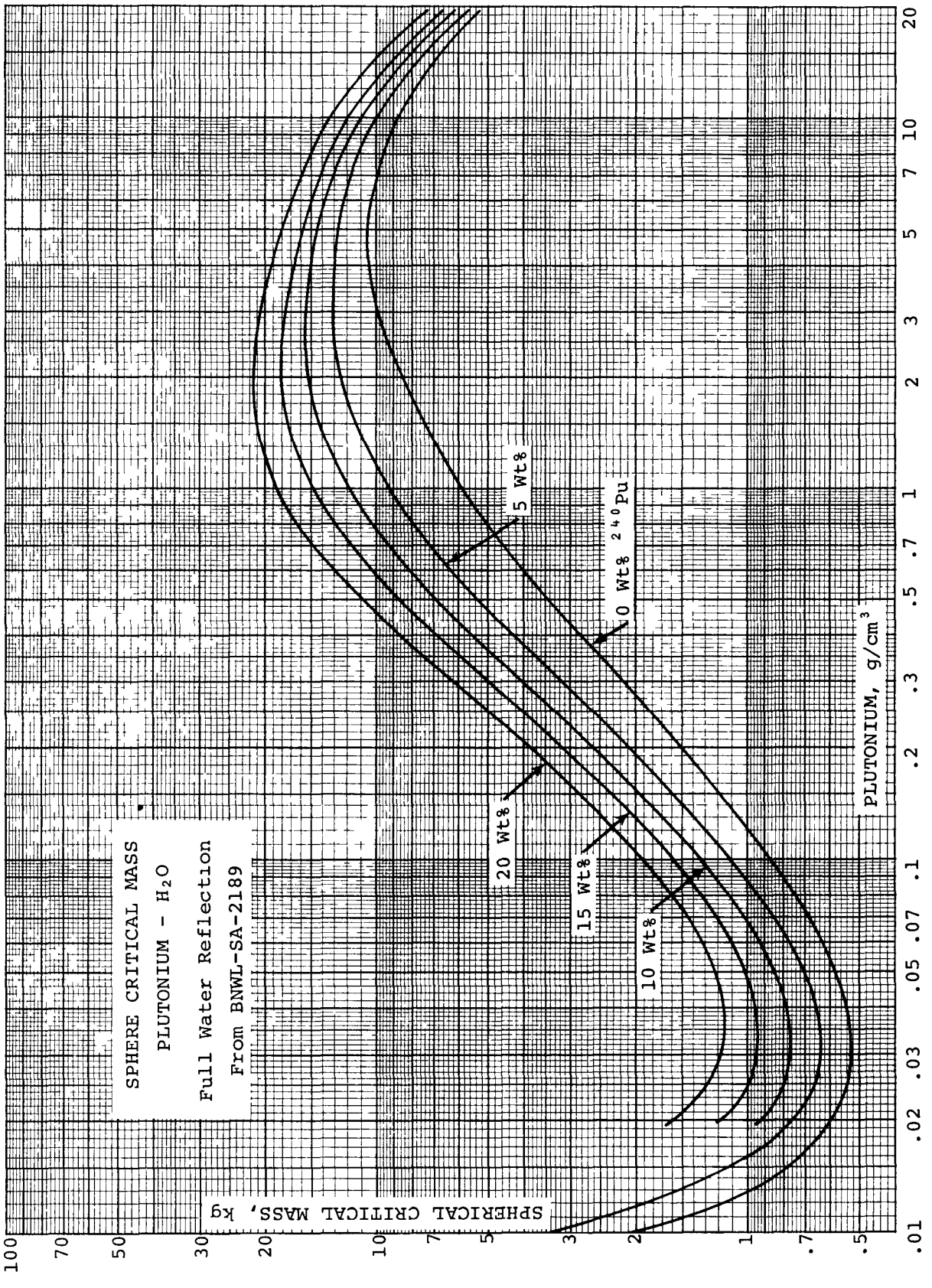

CRITICAL INFINITE SLAB
PLUTONIUM-H_2O - 3 wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
SLAB THICKNESS, in.
PLUTONIUM, g/l
9
8
7
6
5
4
3
2
10
20
30
50
70
100
200
300
500
700
1000

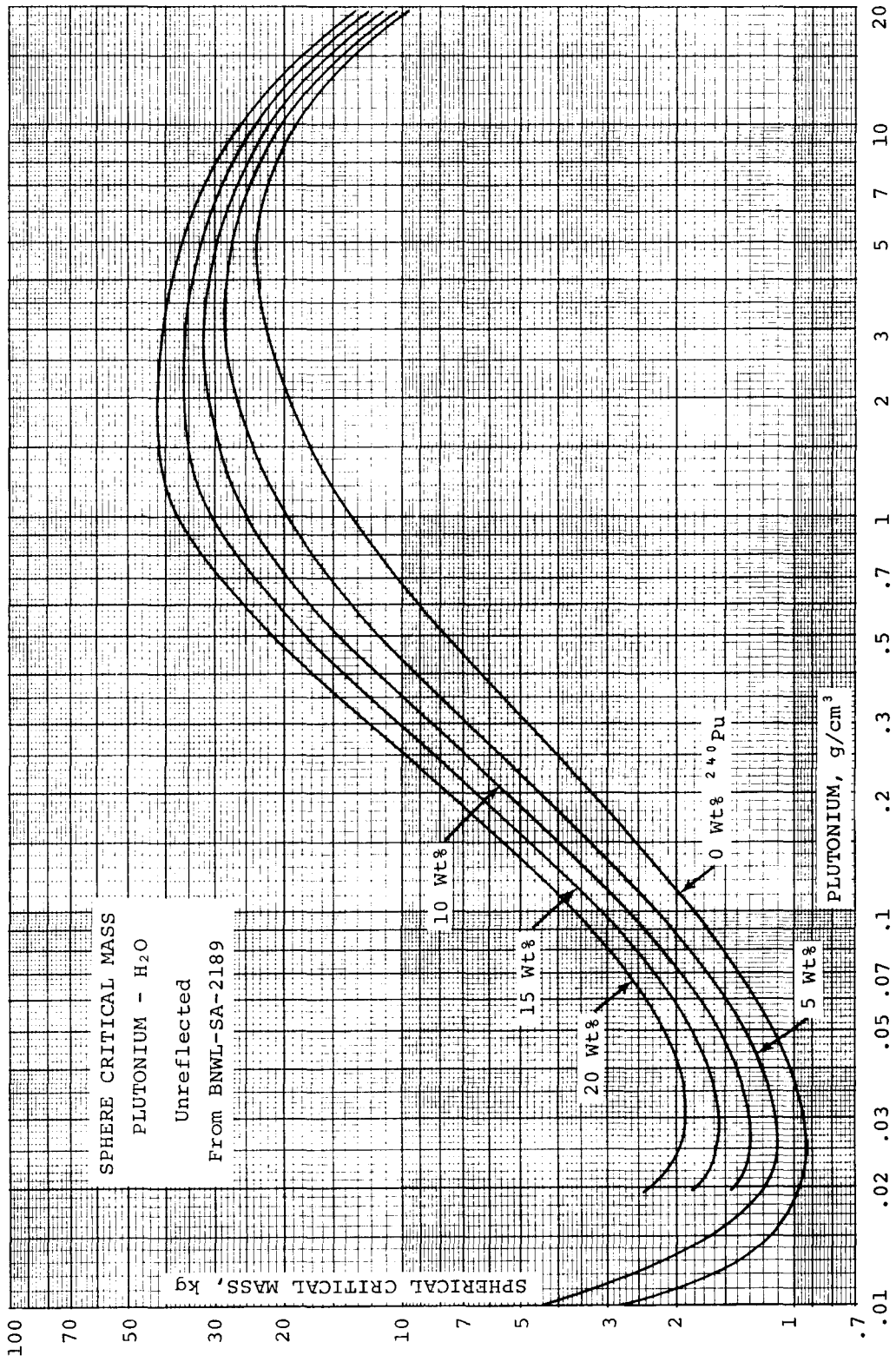

INFINITE SLAB - VARIOUS REFLECTORS
PLUTONIUM NITRATE - 3 Wt% 240, OM
Critical
k = 0.98
1" H2O Both Sides
1" H2O & Full H2O
1" H2O & 10" Concrete
Full H2O Both Sides
10" Concrete Both Sides
SLAB THICKNESS, in.
PLUTONIUM, g/l
8
7
6
5
4
3
2
1
10
20
30
50
70
100
200
300
500
700
1000

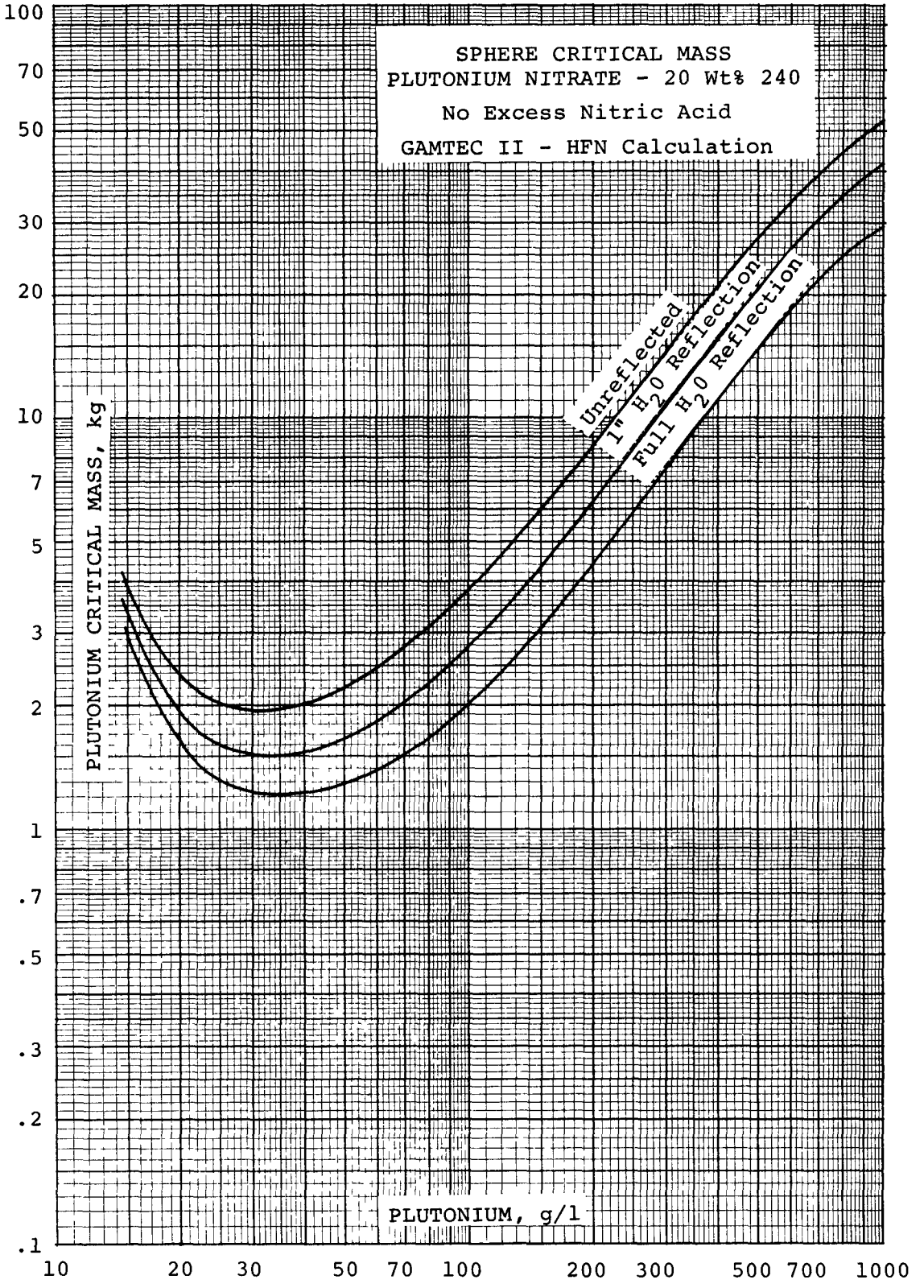

CRITICAL INFINITE SLAB
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Calculation
--- Unreflected
—— Full Water Reflection
UNREFLECTED SLAB THICKNESS, in.
FULLY REFLECTED SLAB THICKNESS, in.
PLUTONIUM, g/l
6M
3M
0M
6M
3M
0M

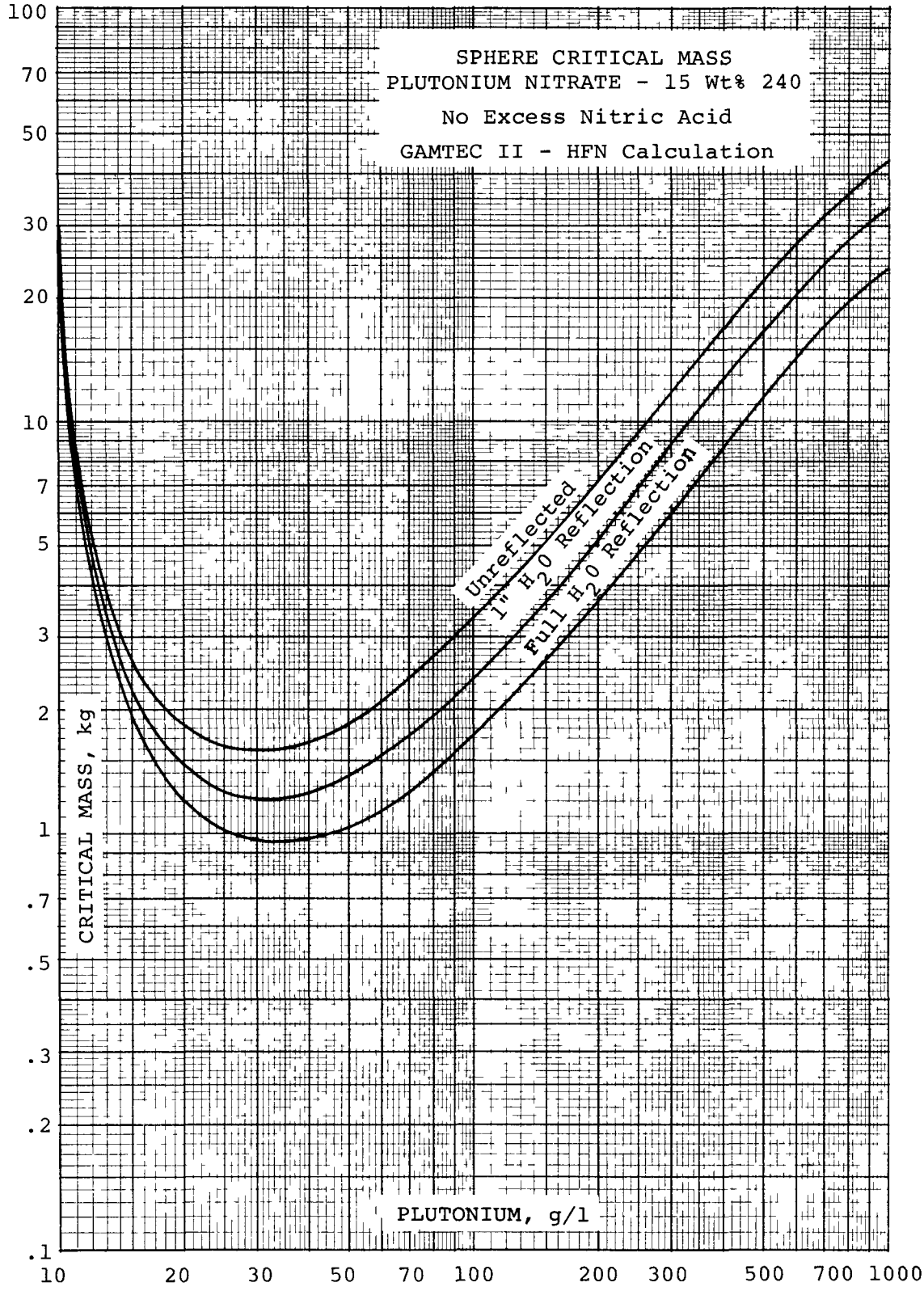

CRITICAL INFINITE SLAB
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 0 wt% 240
GAMTEC II - HFN Calculation
6M
3M
0M
SLAB THICKNESS, in.
PLUTONIUM, g/l
10
9
8
7
6
5
4
3
1000
700
500
300
200
100
70
50
30
20
10

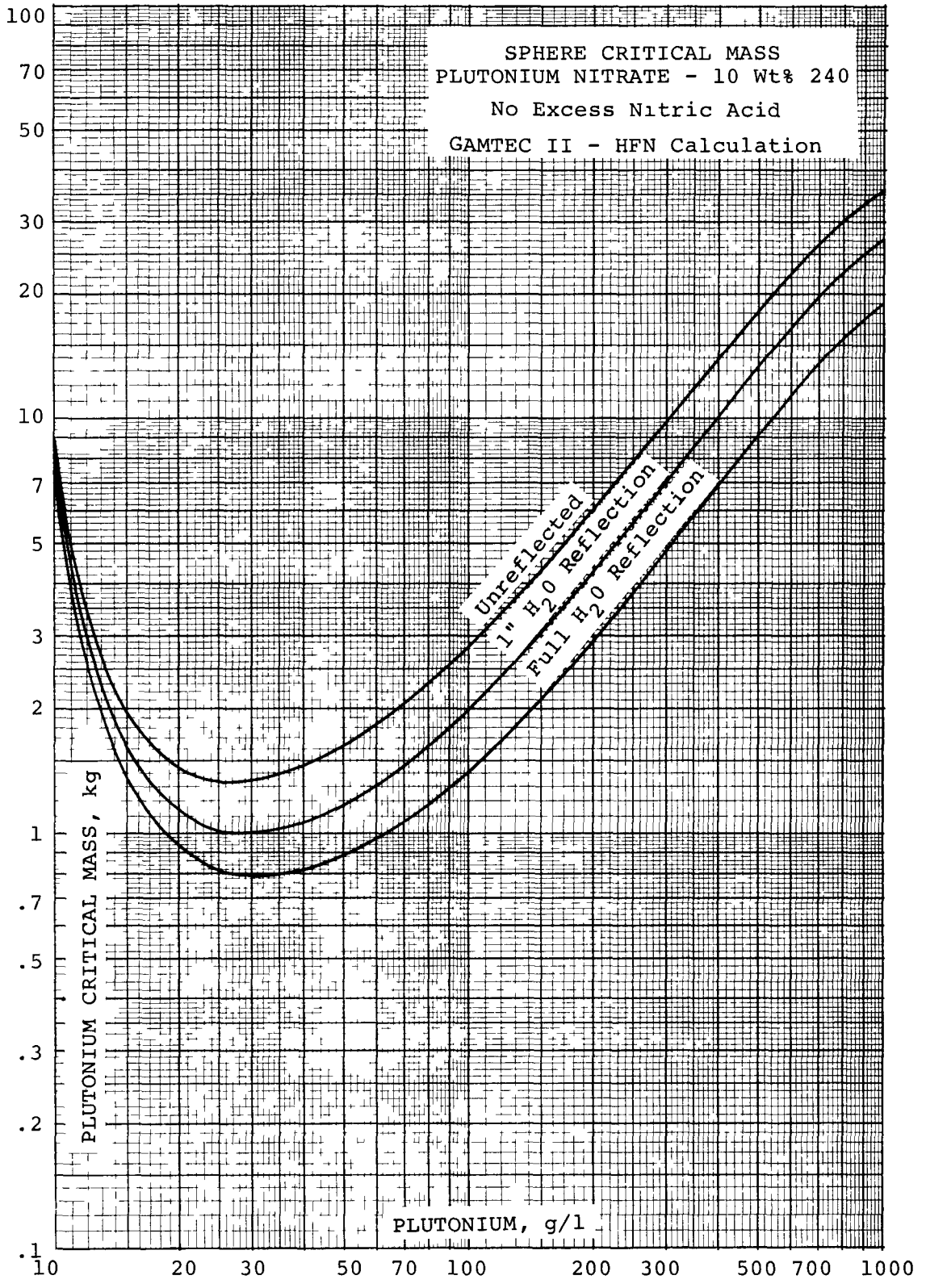

CRITICAL INFINITE SLAB
PLUTONIUM - H_2O - 0 wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H_2O Reflection
Full H_2O Reflection
SLAB THICKNESS, in.
PLUTONIUM, g/l
8
7
6
5
4
3
2
1
10
20
30
50
70
100
200
300
500
700
1000

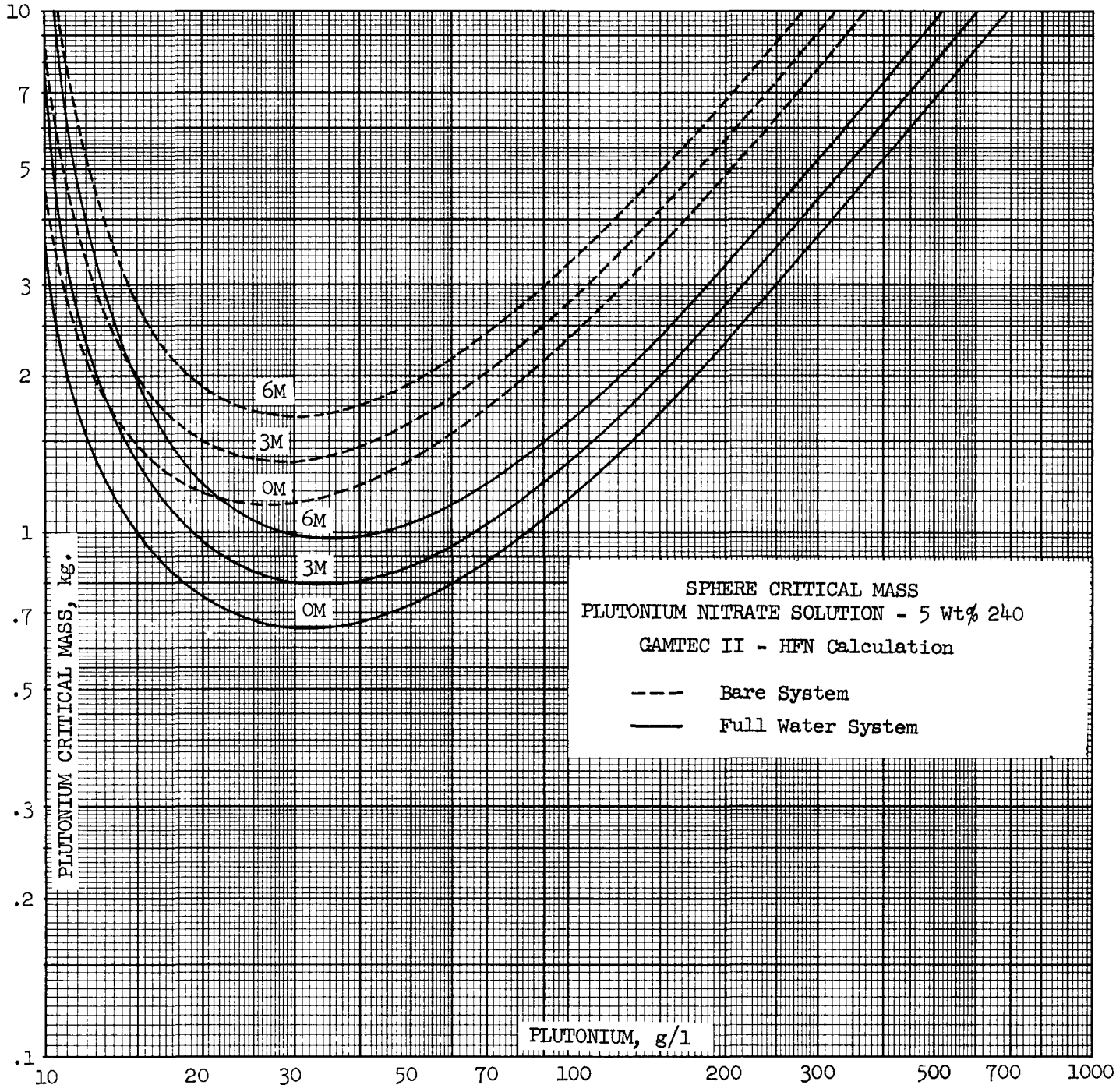

SPHERE CRITICAL MASS
PLUTONIUM - H_2O
Full Water Reflection
From BNWL-SA-2189
SPHERICAL CRITICAL MASS, kg
PLUTONIUM, g/cm³
0 Wt% ²⁴⁰Pu
5 Wt%
10 Wt%
15 Wt%
20 Wt%
100
70
50
30
20
10
7
5
3
2
1
.7
.5
.01
.02
.03
.05
.07
.1
.2
.3
.5
.7
1
2
3
5
7
10
20

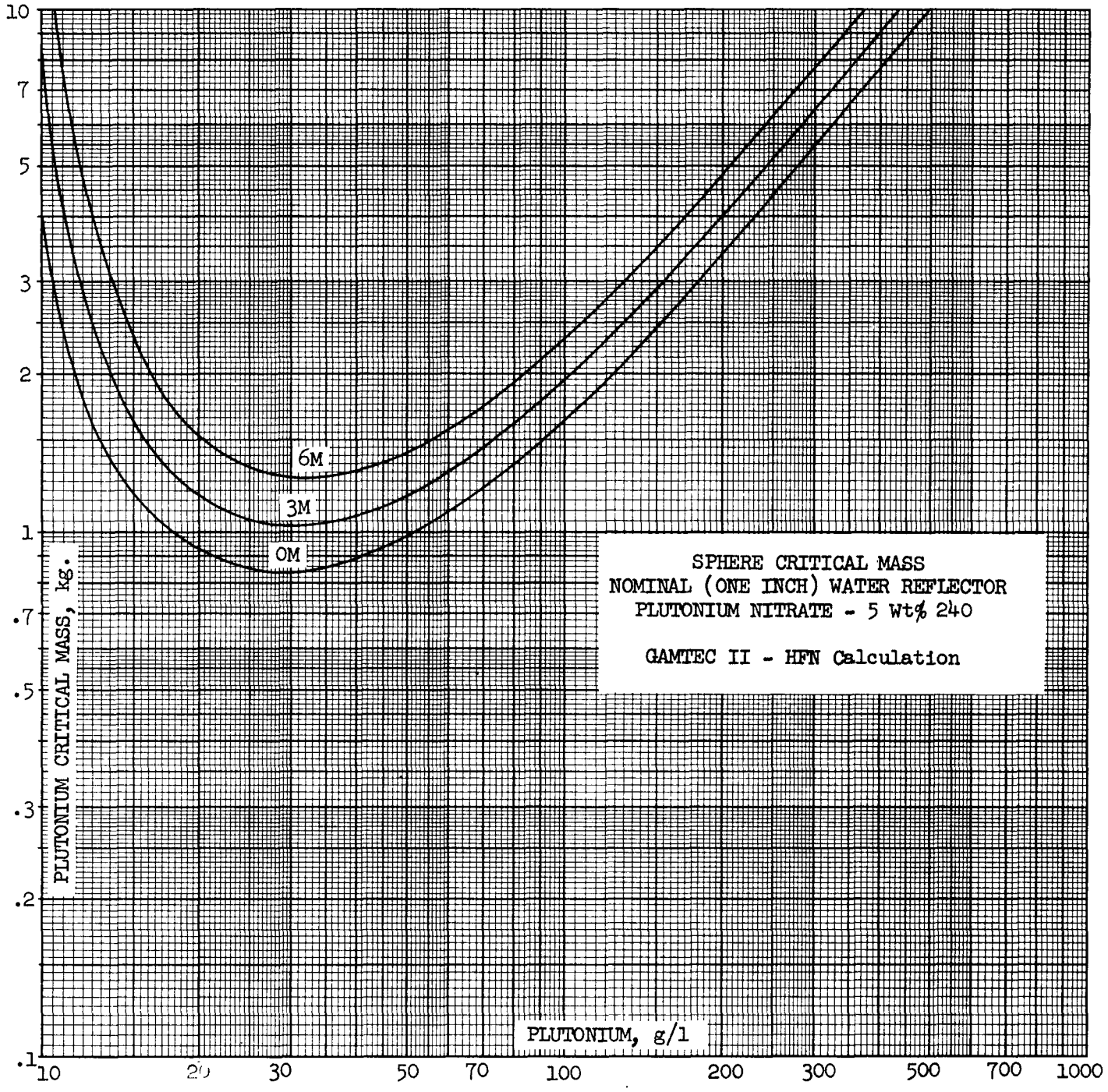

SPHERE CRITICAL MASS
PLUTONIUM - H_2O
Unreflected
From BNWL-SA-2189
SPHERICAL CRITICAL MASS, kg
PLUTONIUM, g/cm³
0 Wt% ^{240}Pu
5 Wt%
10 Wt%
15 Wt%
20 Wt%
100
70
50
30
20
10
7
5
3
2
1
.7
.01
.02
.03
.05
.07
.1
.2
.3
.5
.7
1
2
3
5
7
10
20

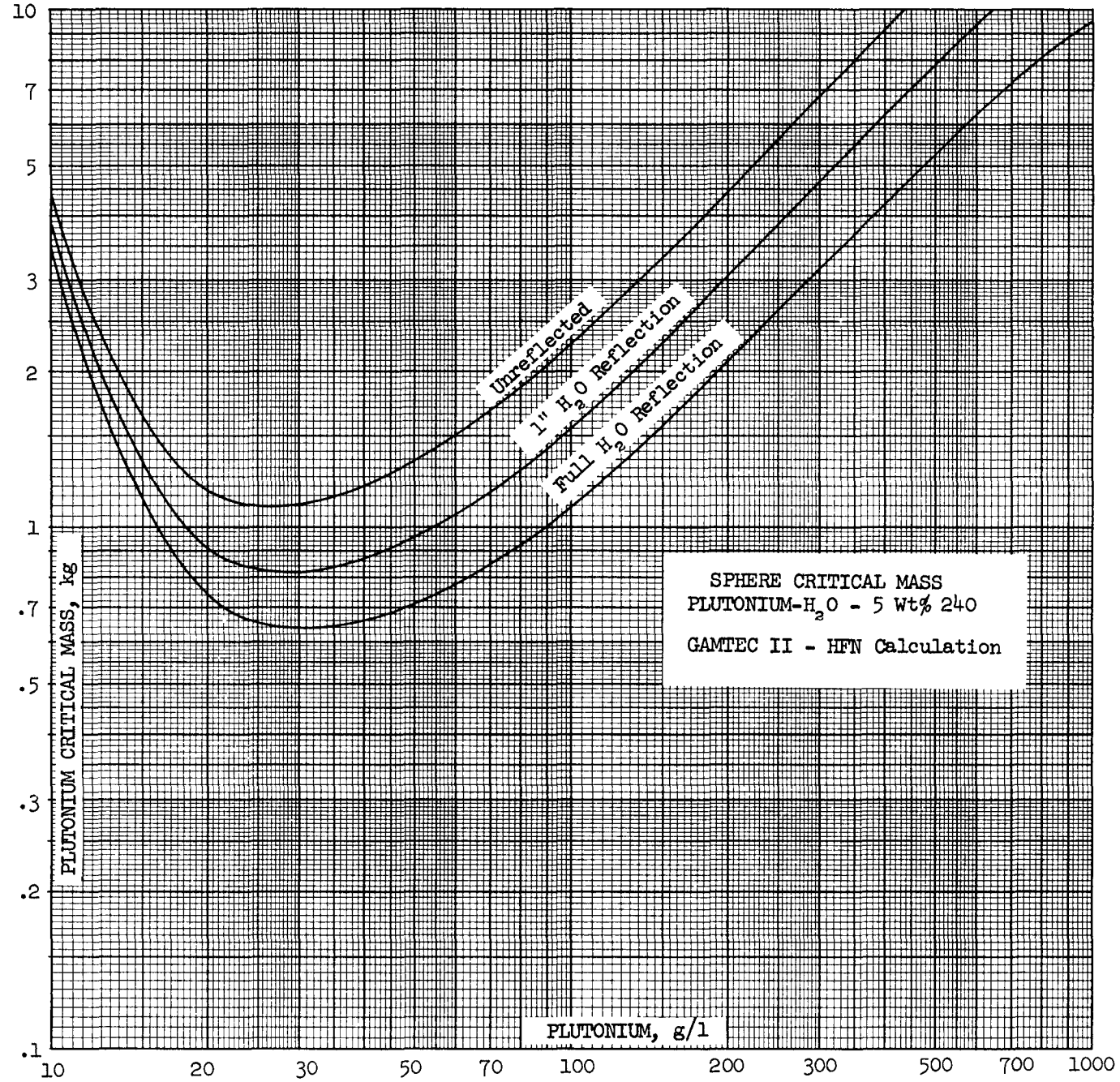

SPHERE CRITICAL MASS
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
Unreflected
1" H2O Reflection
Full H2O Reflection
PLUTONIUM CRITICAL MASS, kg
PLUTONIUM, g/l
100
70
50
30
20
10
7
5
3
2
1
.7
.5
.3
.2
.1
10
20
30
50
70
100
200
300
500
700
1000

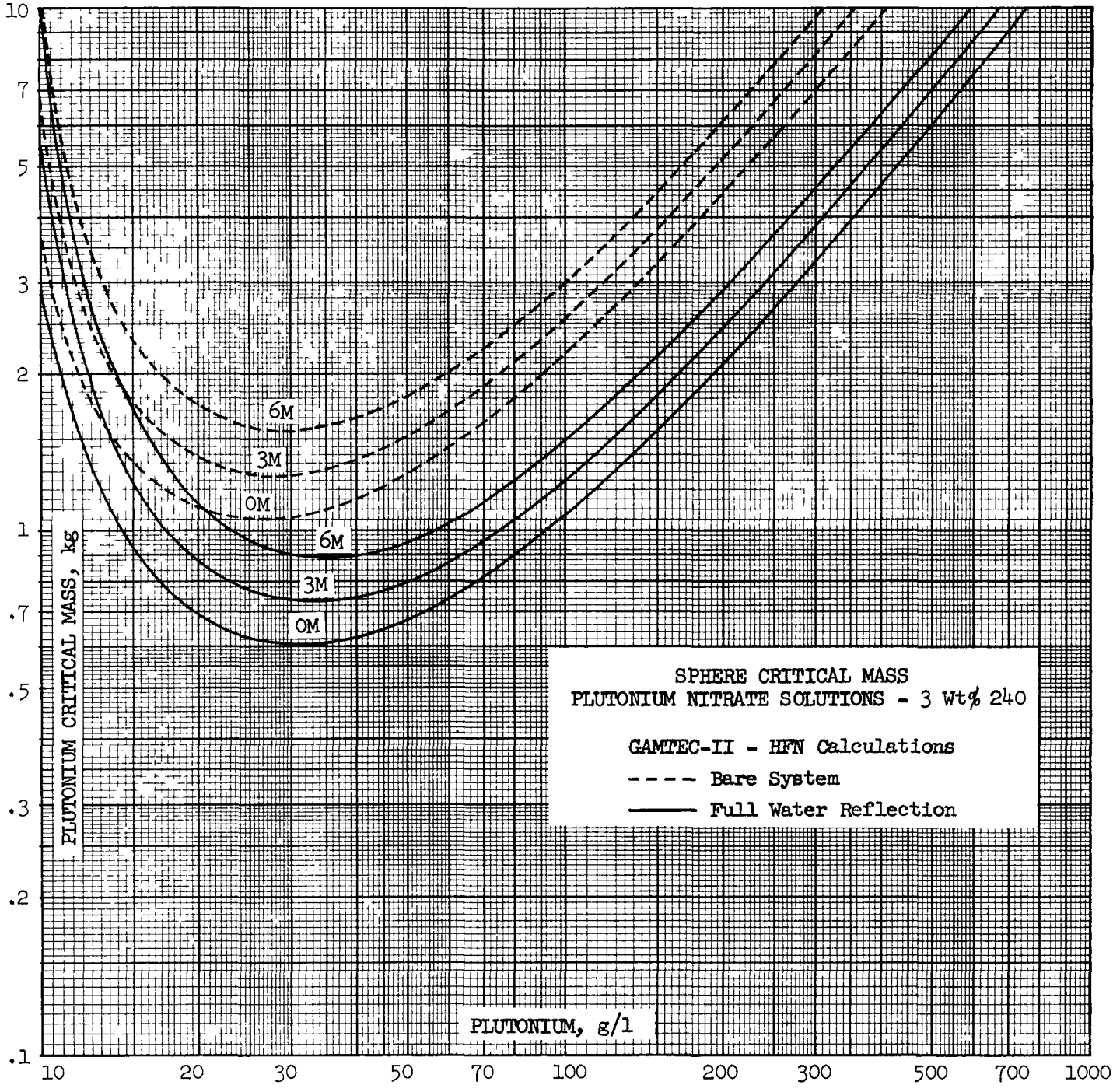

SPHERE CRITICAL MASS
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
Unreflected
1" H2O Reflection
Full H2O Reflection
CRITICAL MASS, kg
PLUTONIUM, g/l
100
70
50
30
20
10
7
5
3
2
1
.7
.5
.3
.2
.1
10
20
30
50
70
100
200
300
500
700
1000

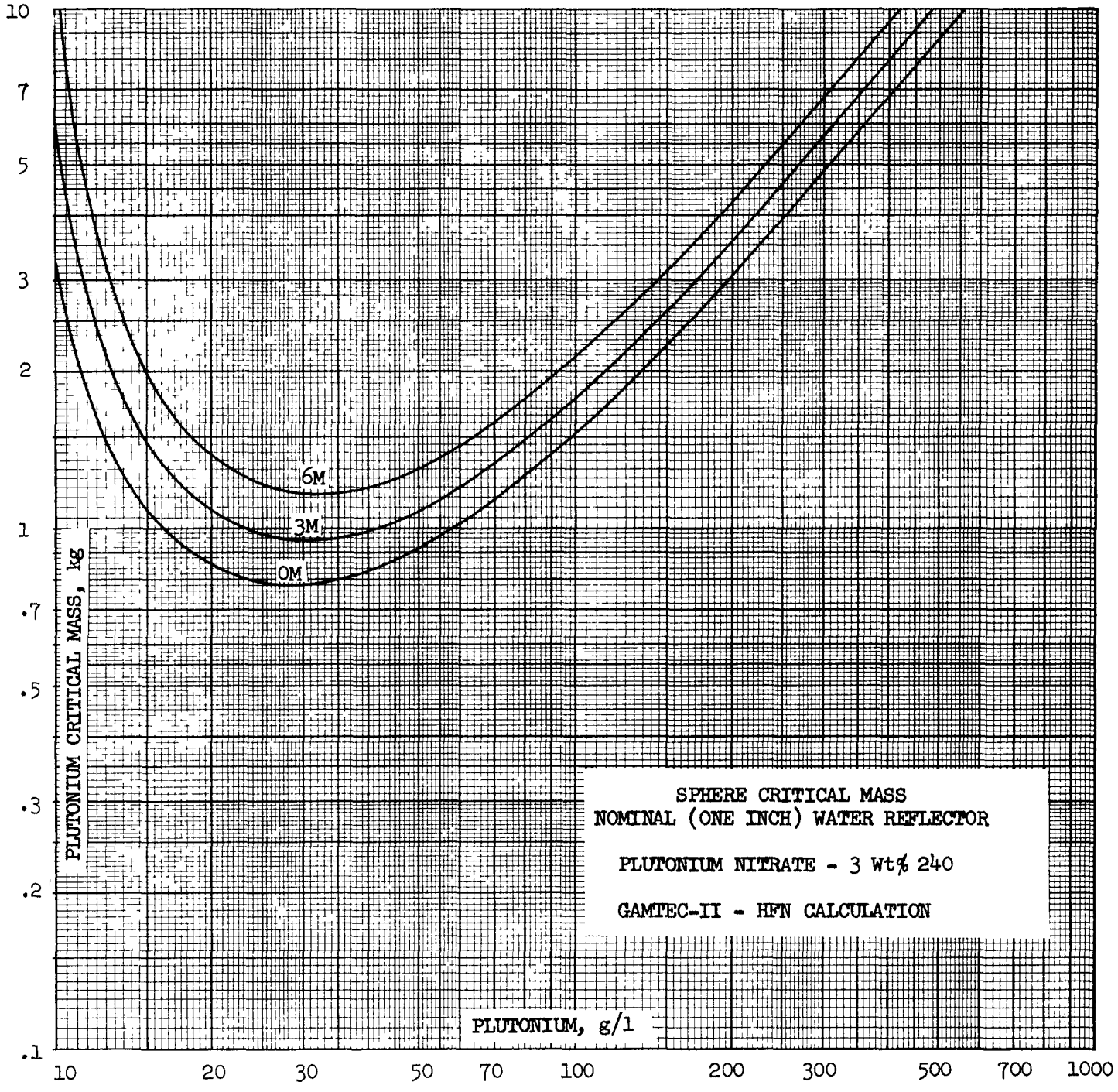

SPHERE CRITICAL MASS
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
PLUTONIUM CRITICAL MASS, kg
PLUTONIUM, g/l
Unreflected
1" H2O Reflection
Full H2O Reflection
100
70
50
30
20
10
7
5
3
2
1
.7
.5
.3
.2
.1
10
20
30
50
70
100
200
300
500
700
1000

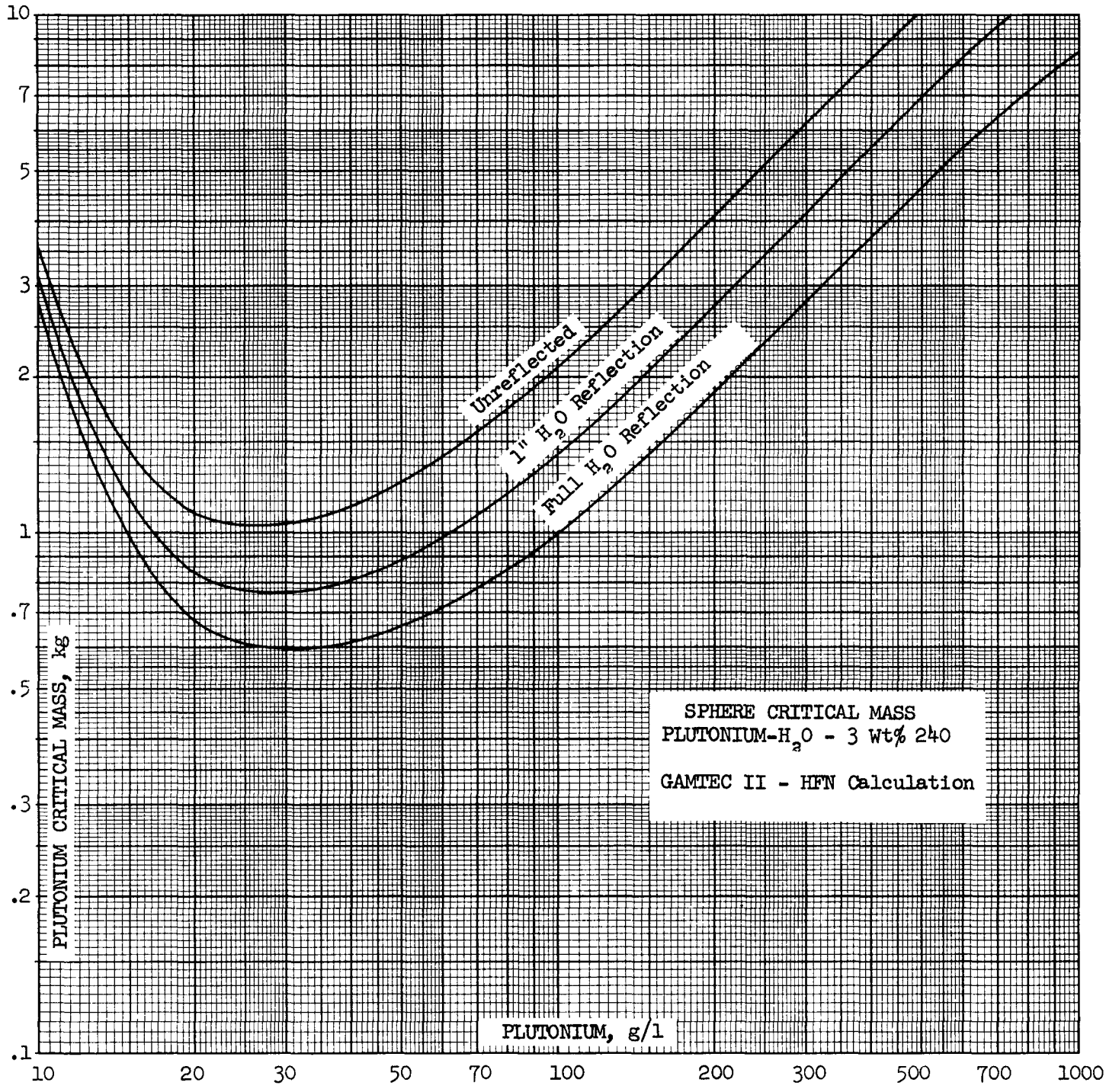

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg.
6M
3M
0M
6M
3M
0M
SPHERE CRITICAL MASS
PLUTONIUM NITRATE SOLUTION - 5 Wt% 240
GAMTEC II - HFN Calculation
--- Bare System
—— Full Water System
10
20
30
50
70
100
200
300
500
700
1000
PLUTONIUM, g/l

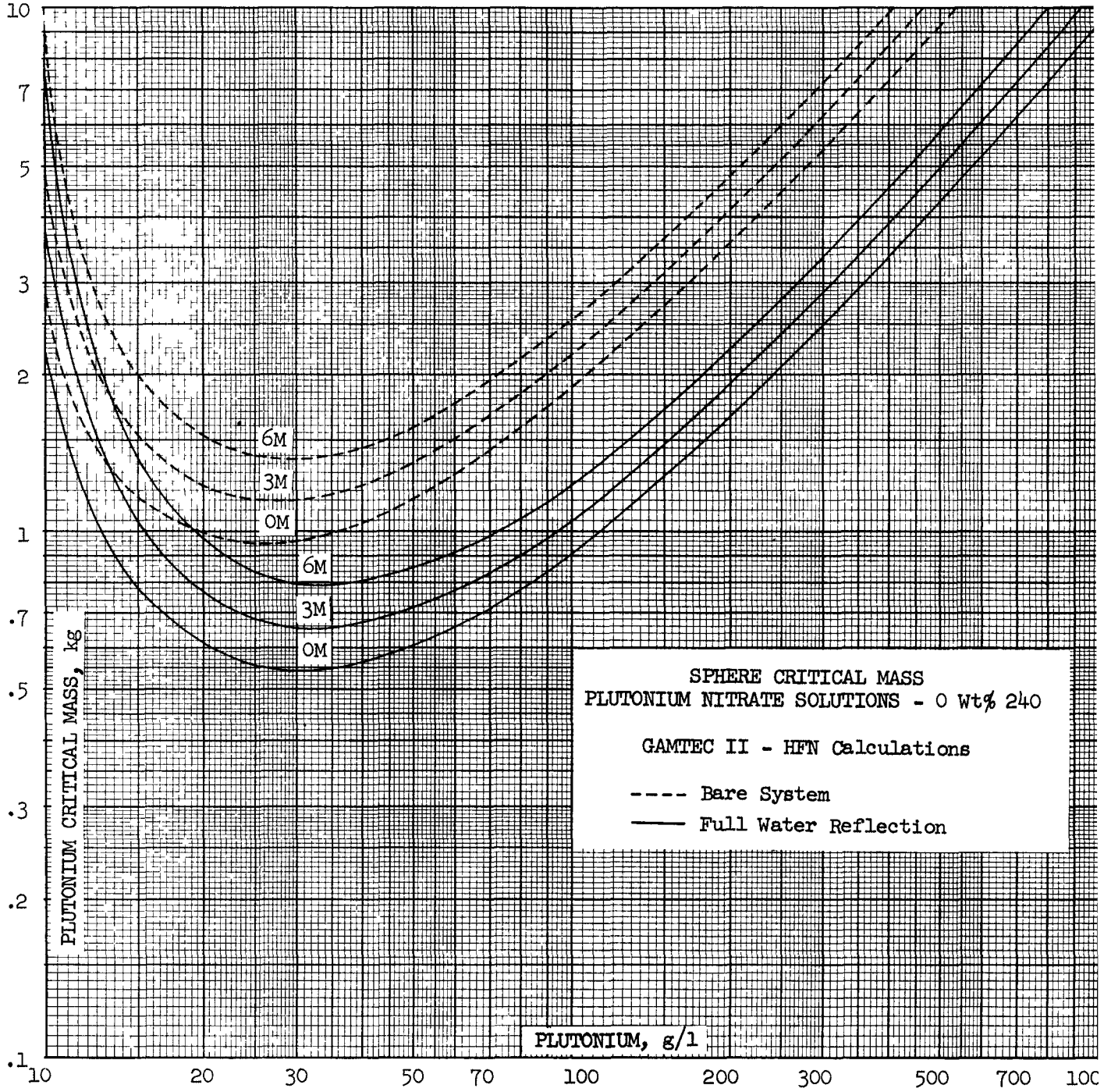

SPHERE CRITICAL MASS
NOMINAL (ONE INCH) WATER REFLECTOR
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculation
6M
3M
0M
PLUTONIUM CRITICAL MASS, kg.
PLUTONIUM, g/l
10
7
5
3
2
1
.7
.5
.3
.2
.1
10
20
30
50
70
100
200
300
500
700
1000

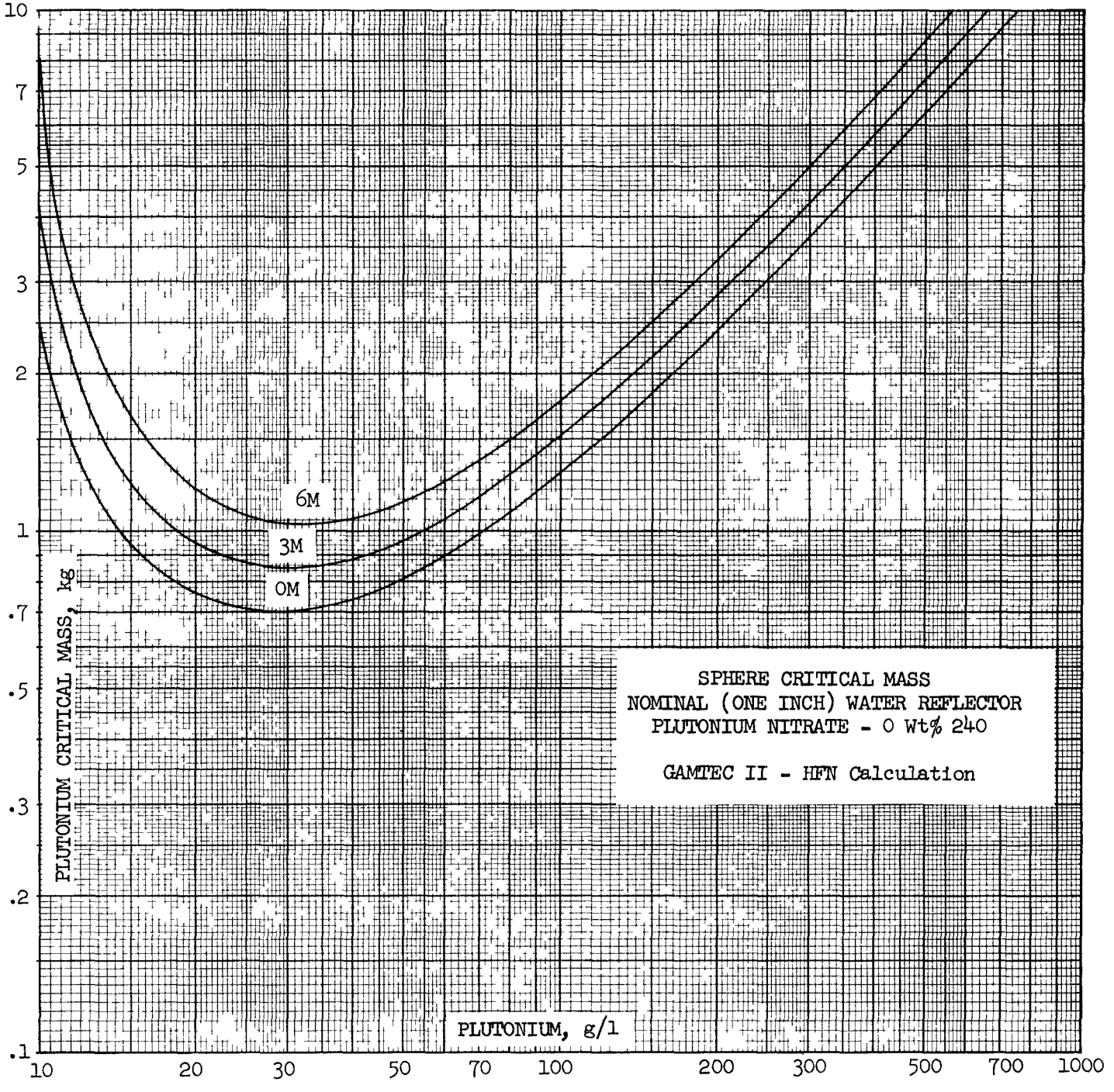

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg
Unreflected
1" H2O Reflection
Full H2O Reflection
SPHERE CRITICAL MASS
PLUTONIUM-H2O - 5 Wt% 240
GAMTEC II - HFN Calculation
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

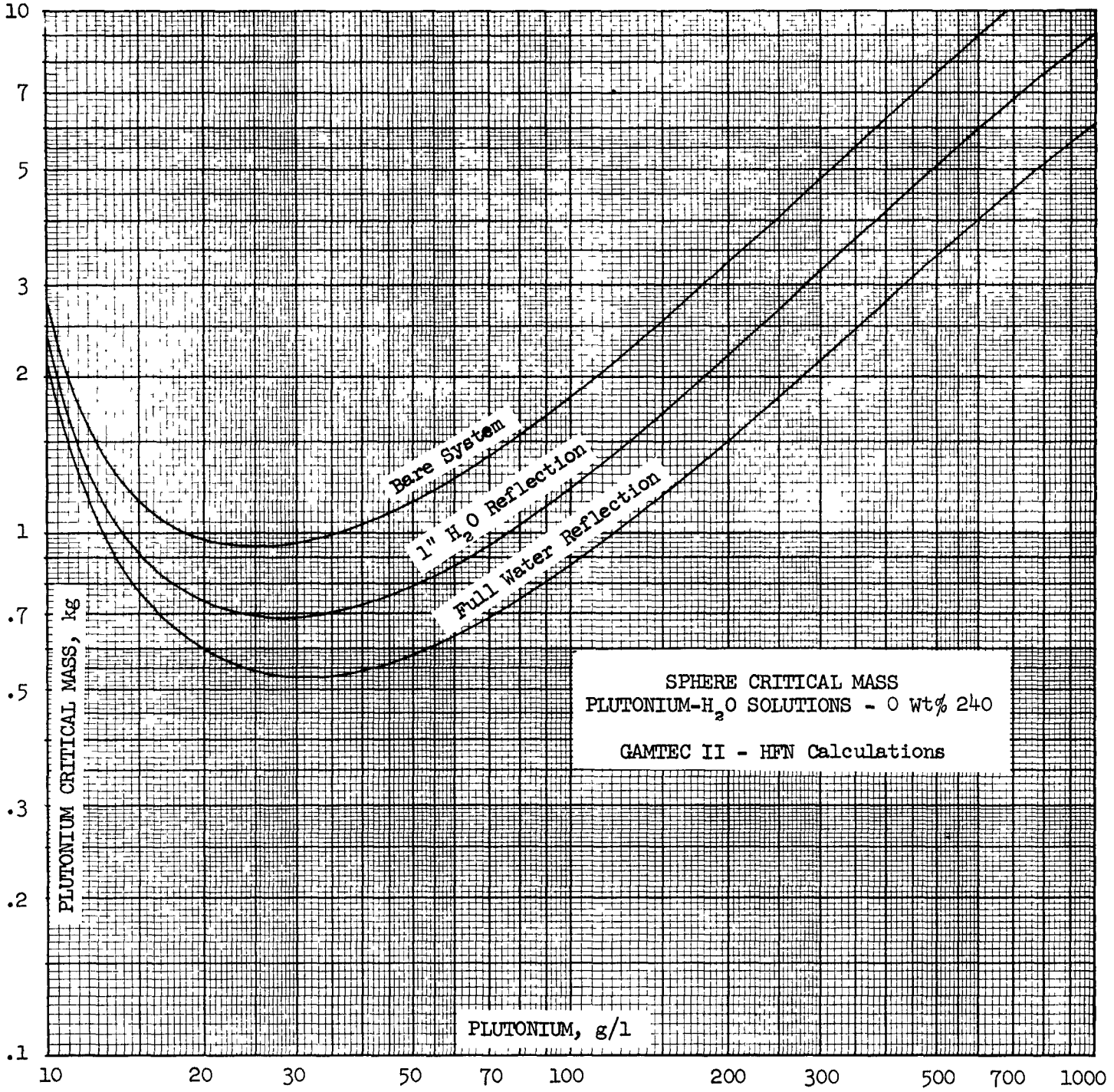

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg
6M
3M
0M
6M
3M
0M
SPHERE CRITICAL MASS
PLUTONIUM NITRATE SOLUTIONS - 3 Wt% 240
GAMTEC-II - HFN Calculations
---- Bare System
——— Full Water Reflection
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

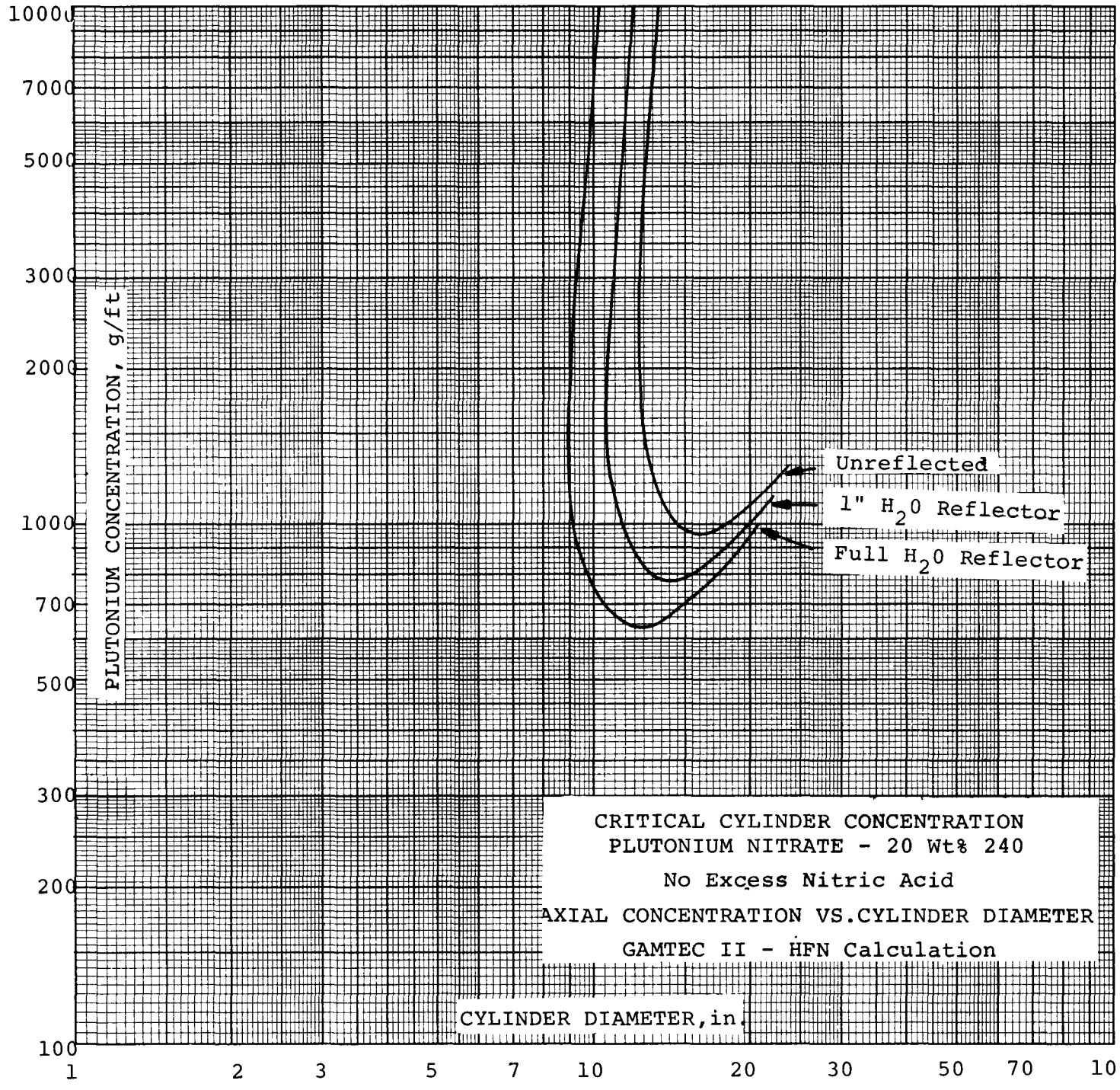

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg
6M
3M
0M
SPHERE CRITICAL MASS
NOMINAL (ONE INCH) WATER REFLECTOR
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-II - HFN CALCULATION
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

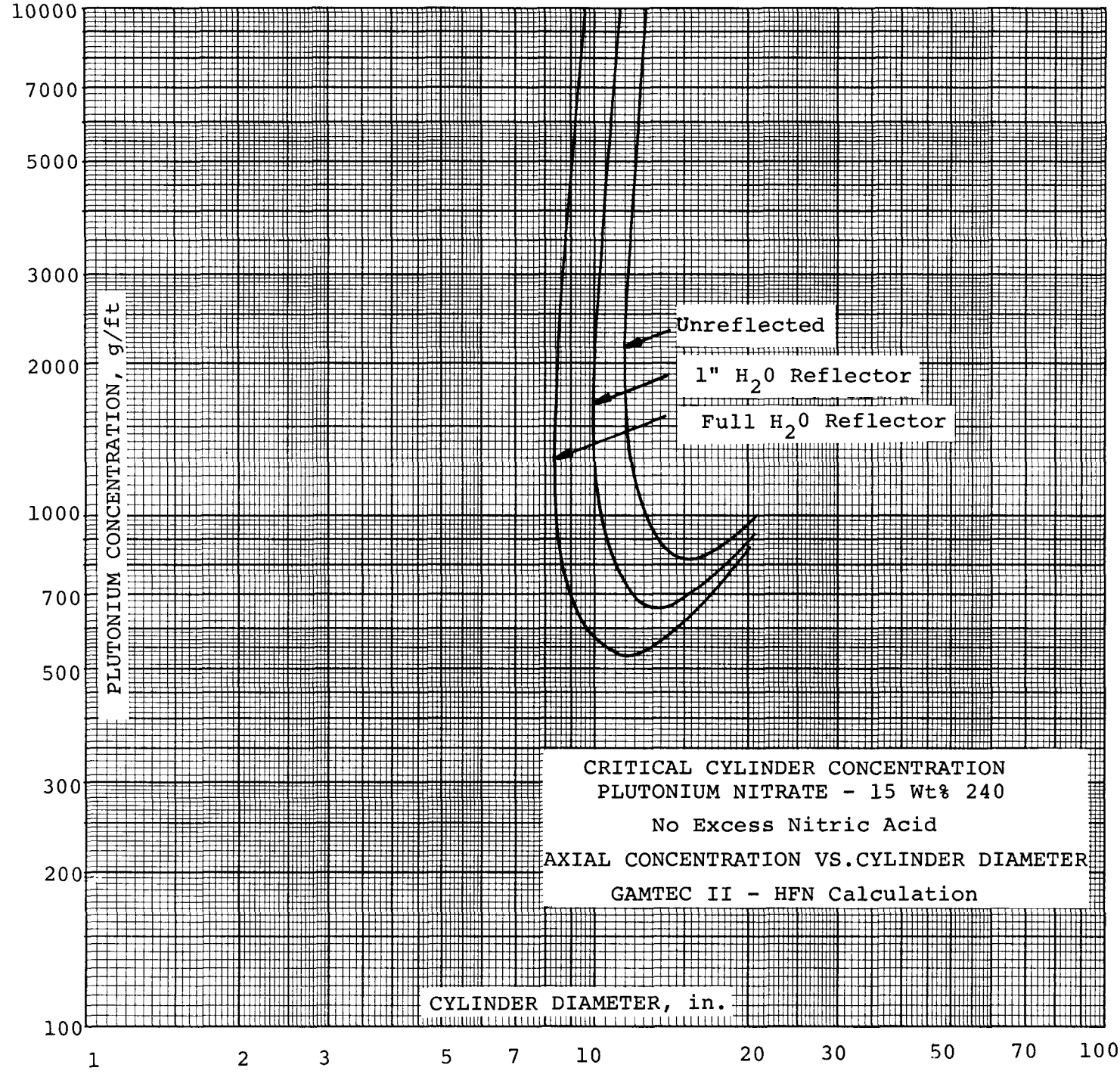

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg
Unreflected
1" H_2O Reflection
Full H_2O Reflection
SPHERE CRITICAL MASS
PLUTONIUM-H_2O - 3 Wt% 240
GAMTEC II - HFN Calculation
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

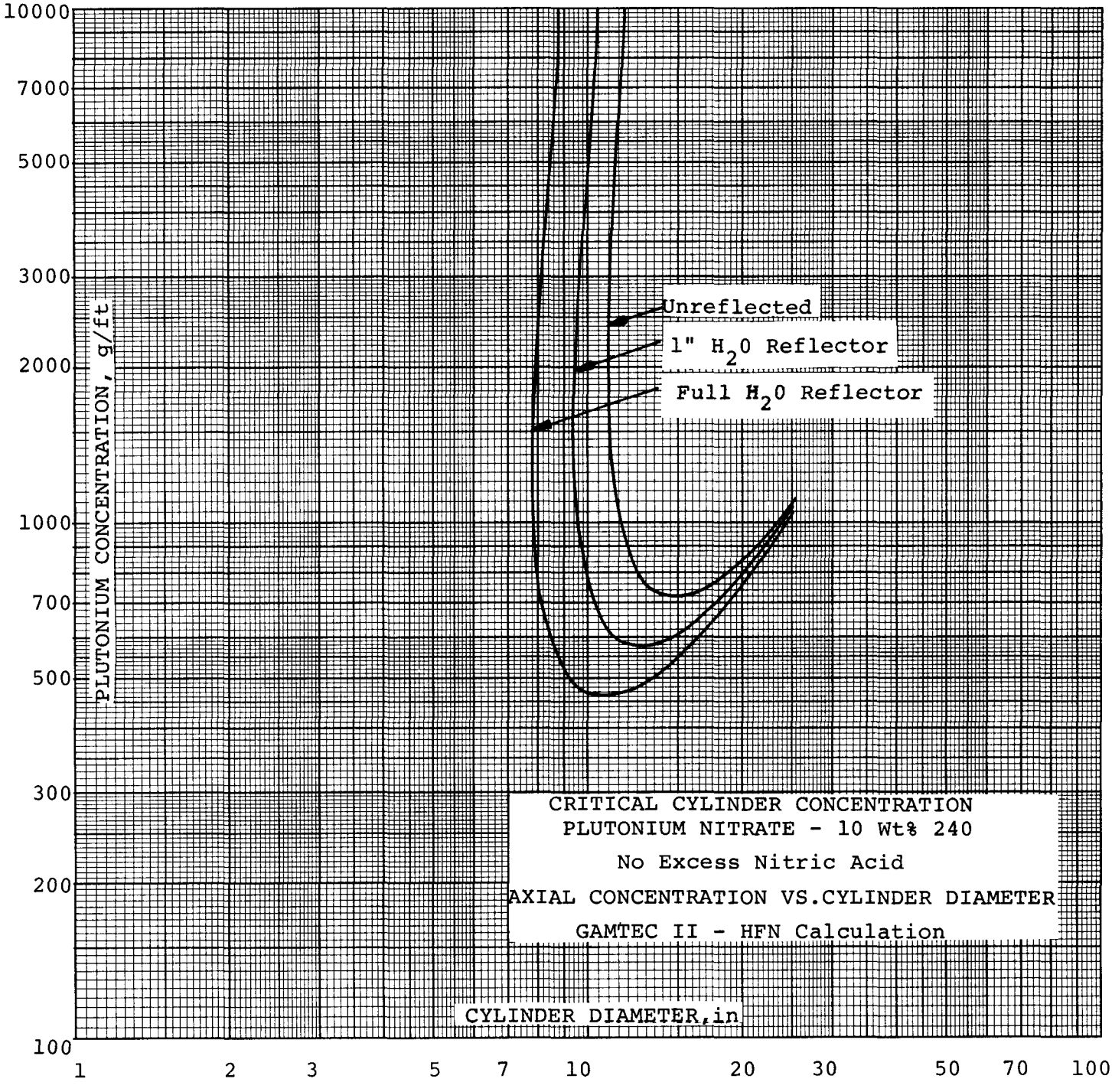

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg
6M
3M
0M
6M
3M
0M
SPHERE CRITICAL MASS
PLUTONIUM NITRATE SOLUTIONS - 0 Wt% 240
GAMTEC II - HFN Calculations
---- Bare System
—— Full Water Reflection
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
100

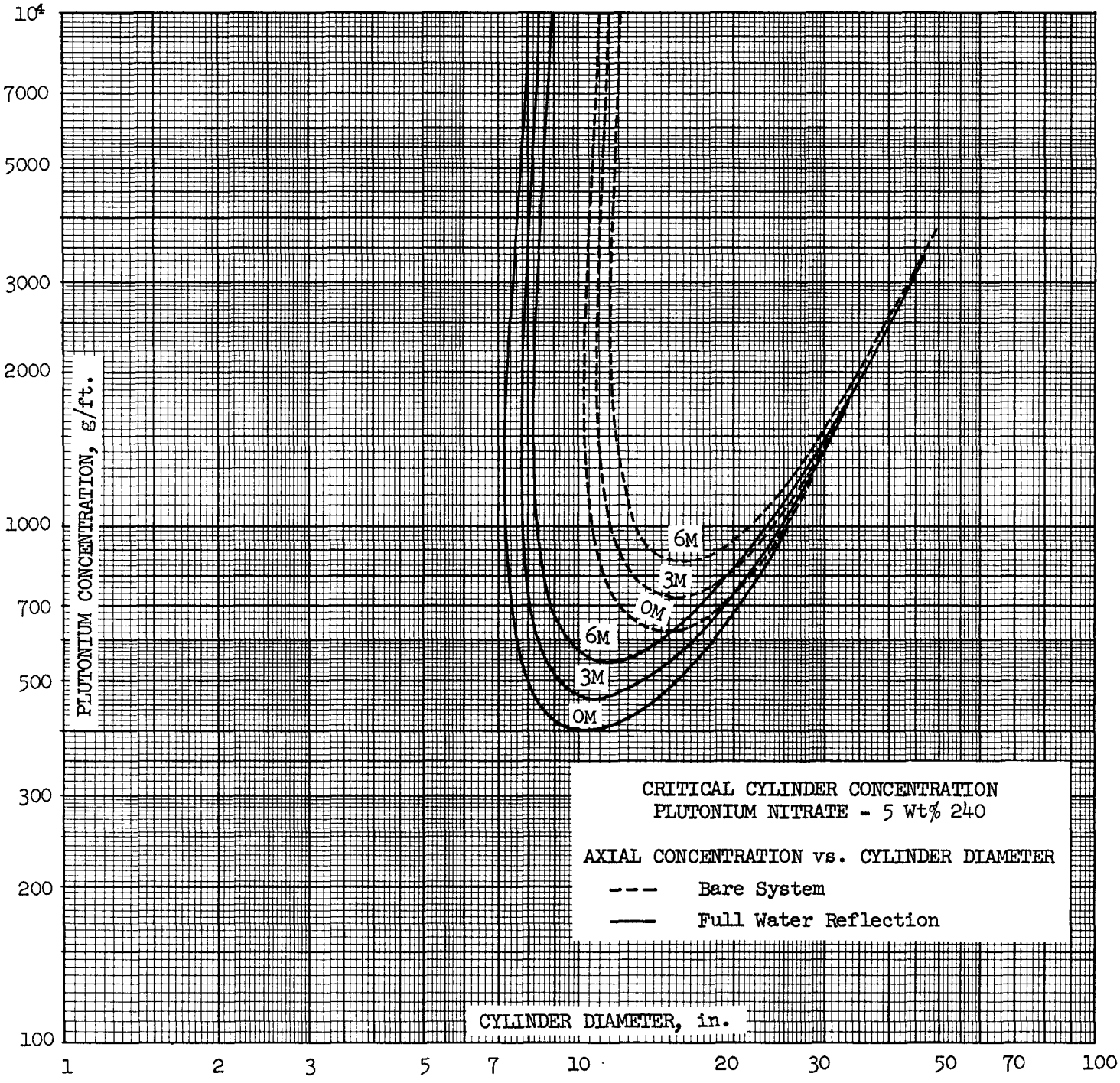

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg
6M
3M
0M
SPHERE CRITICAL MASS
NOMINAL (ONE INCH) WATER REFLECTOR
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Calculation
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

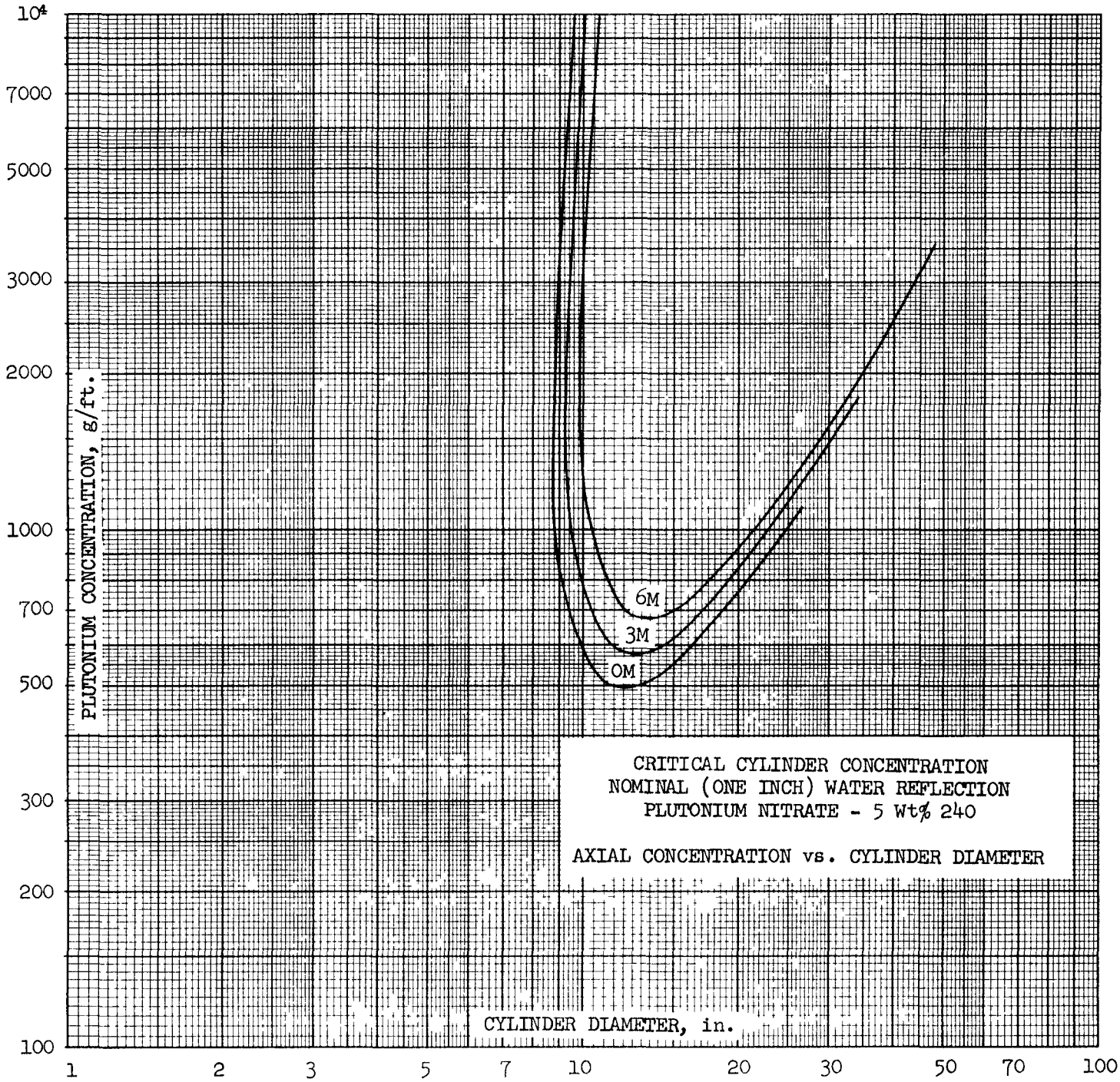

10
7
5
3
2
1
.7
.5
.3
.2
.1
PLUTONIUM CRITICAL MASS, kg
Bare System
1" H_2O Reflection
Full Water Reflection
SPHERE CRITICAL MASS
PLUTONIUM-H_2O SOLUTIONS - 0 Wt% 240
GAMTEC II - HFN Calculations
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

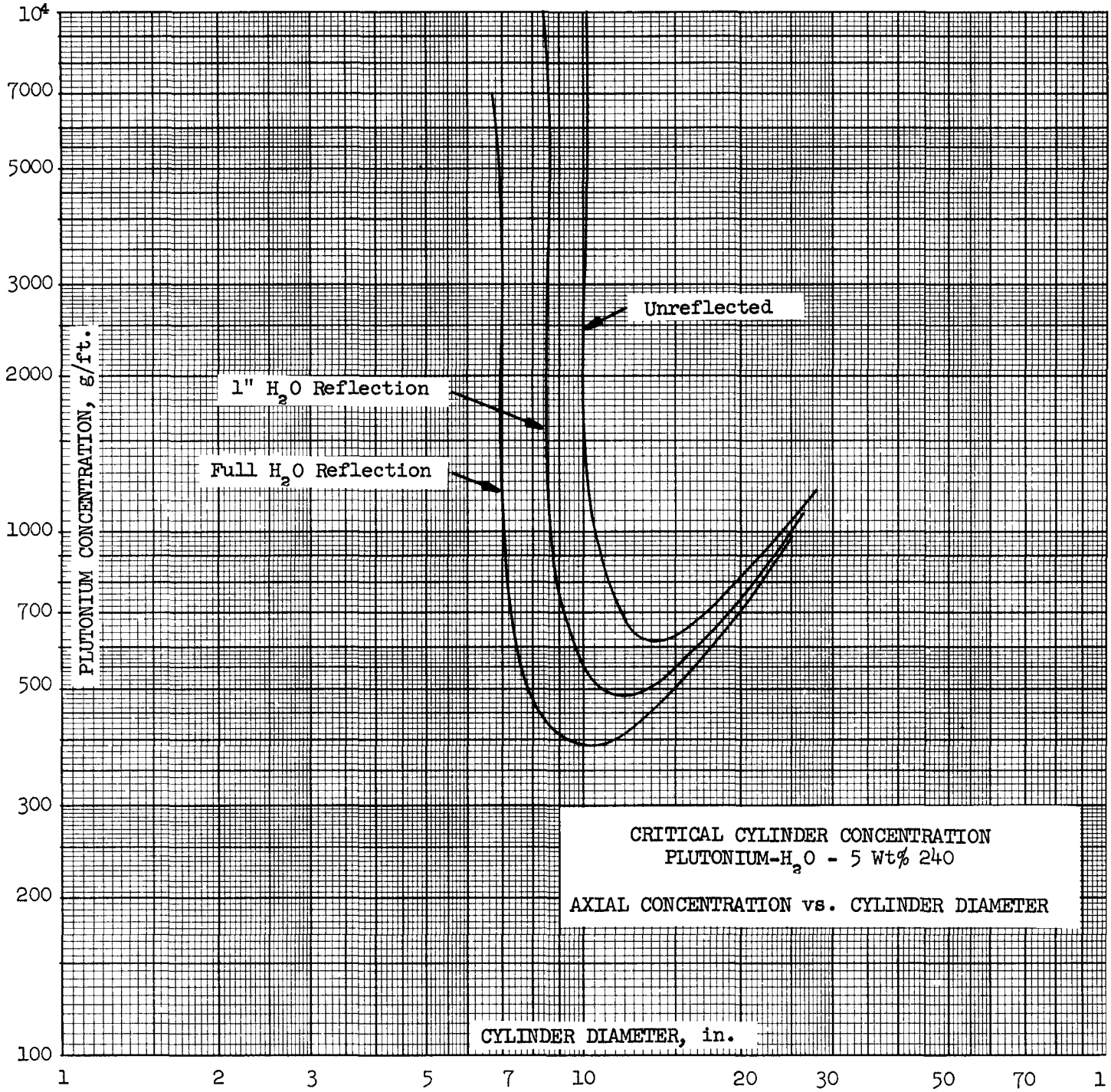

PLUTONIUM CONCENTRATION, g/ft
1000
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100
CYLINDER DIAMETER, in.
Unreflected
1" H_2O Reflector
Full H_2O Reflector
CRITICAL CYLINDER CONCENTRATION
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
AXIAL CONCENTRATION VS. CYLINDER DIAMETER
GAMTEC II - HFN Calculation

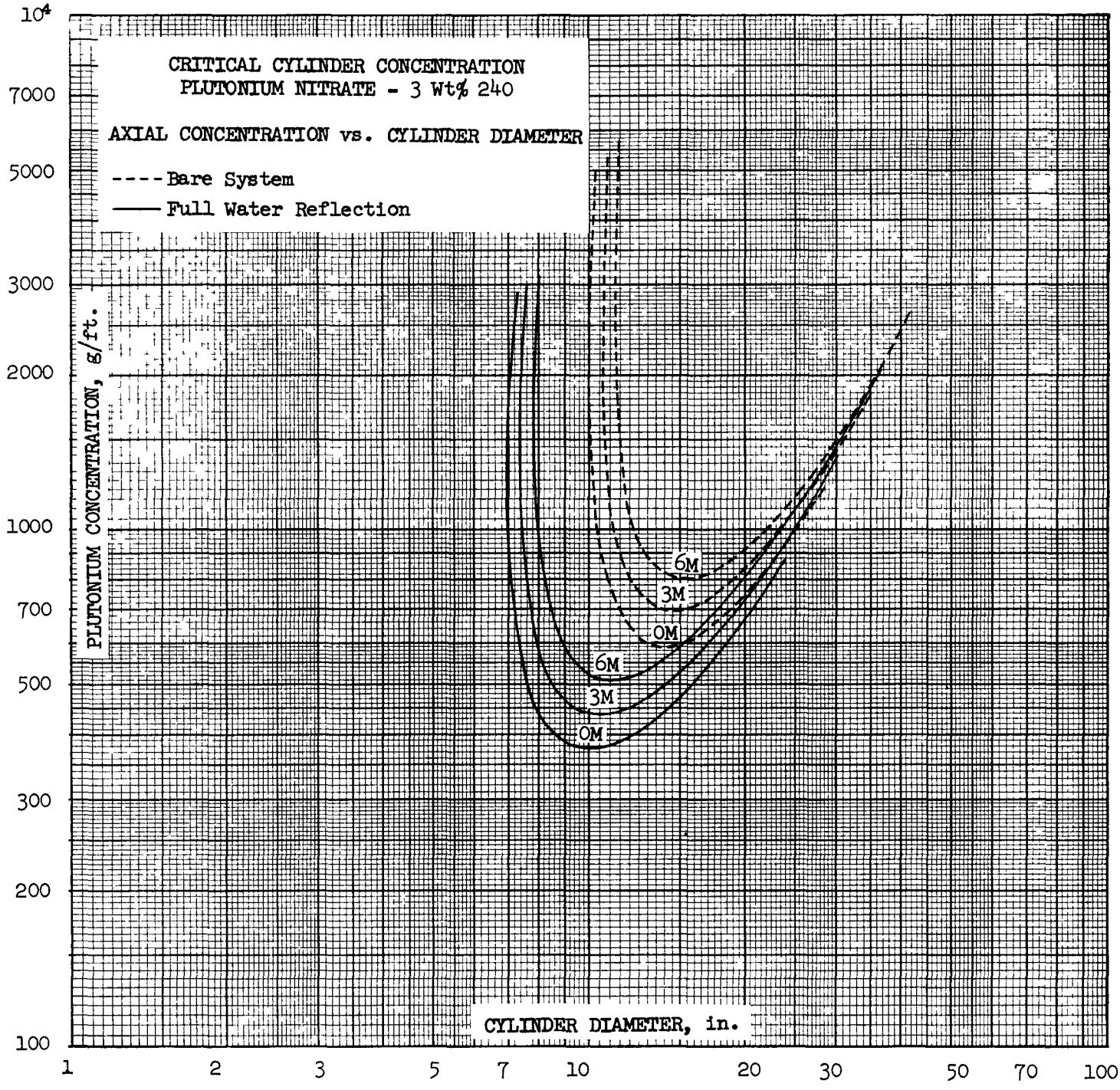

10000
7000
5000
3000
2000
1000
700
500
300
200
100
PLUTONIUM CONCENTRATION, g/ft
Unreflected
1" H2O Reflector
Full H2O Reflector
CRITICAL CYLINDER CONCENTRATION
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
AXIAL CONCENTRATION VS.CYLINDER DIAMETER
GAMTEC II - HFN Calculation
CYLINDER DIAMETER, in.
1
2
3
5
7
10
20
30
50
70
100

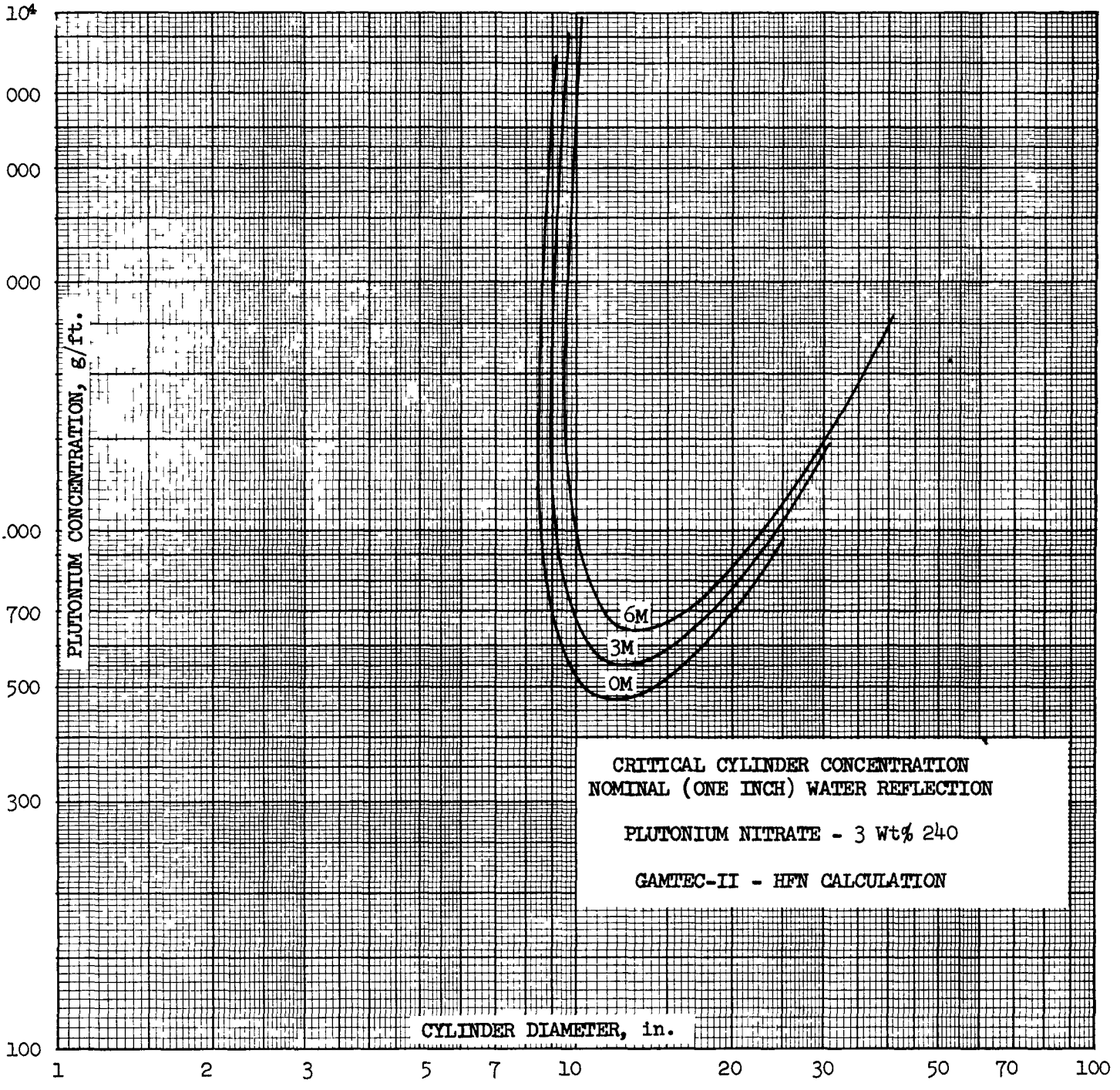

10000
7000
5000
3000
2000
1000
700
500
300
200
100
PLUTONIUM CONCENTRATION, g/ft
Unreflected
1" H_2O Reflector
Full H_2O Reflector
CRITICAL CYLINDER CONCENTRATION
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
AXIAL CONCENTRATION VS.CYLINDER DIAMETER
GAMTEC II - HFN Calculation
CYLINDER DIAMETER,in
1
2
3
5
7
10
20
30
50
70
100

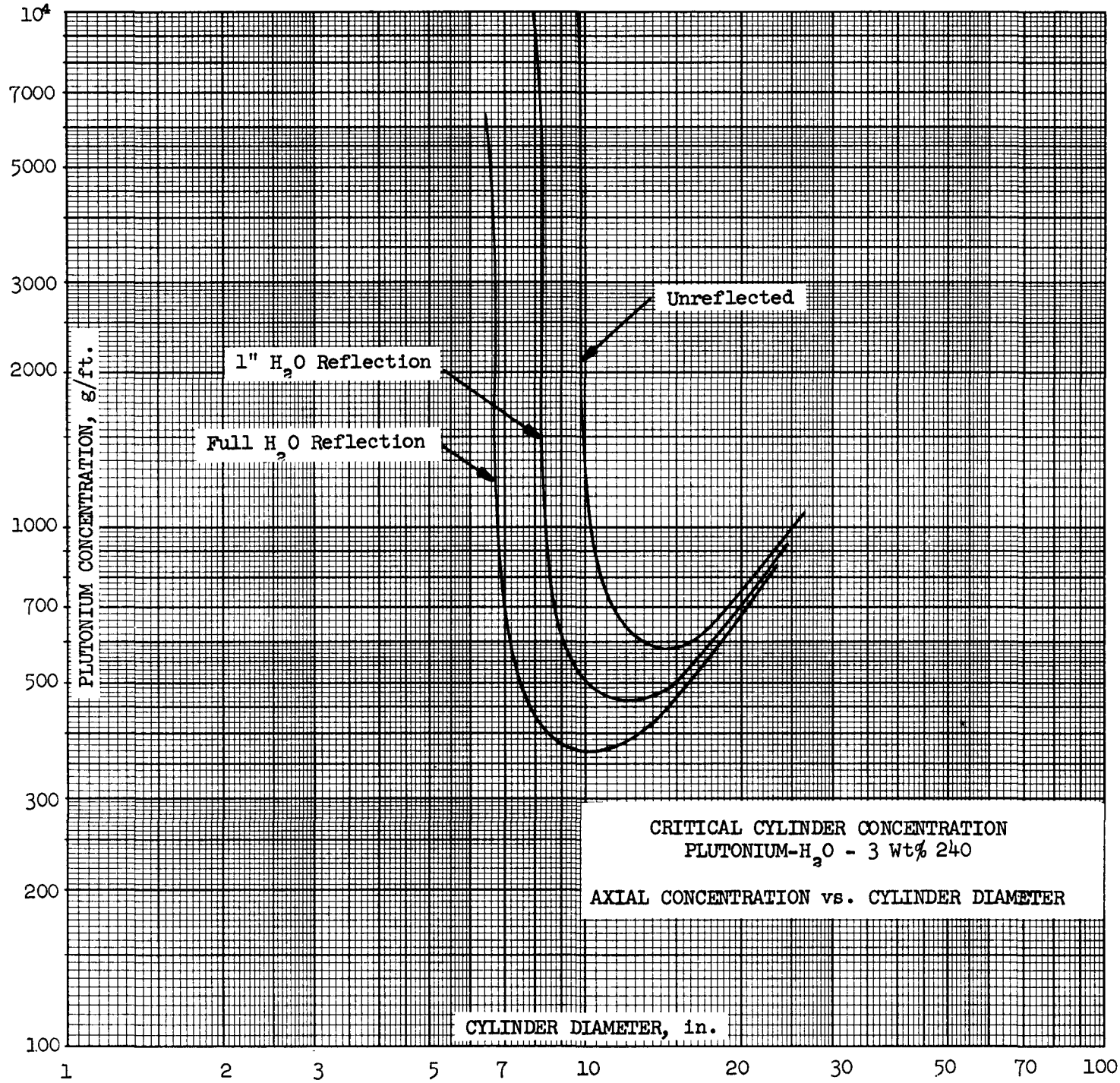

PLUTONIUM CONCENTRATION, g/ft.
10^4
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100
CYLINDER DIAMETER, in.
6M
3M
0M
6M
3M
0M
CRITICAL CYLINDER CONCENTRATION
PLUTONIUM NITRATE - 5 Wt% 240
AXIAL CONCENTRATION vs. CYLINDER DIAMETER
--- Bare System
—— Full Water Reflection

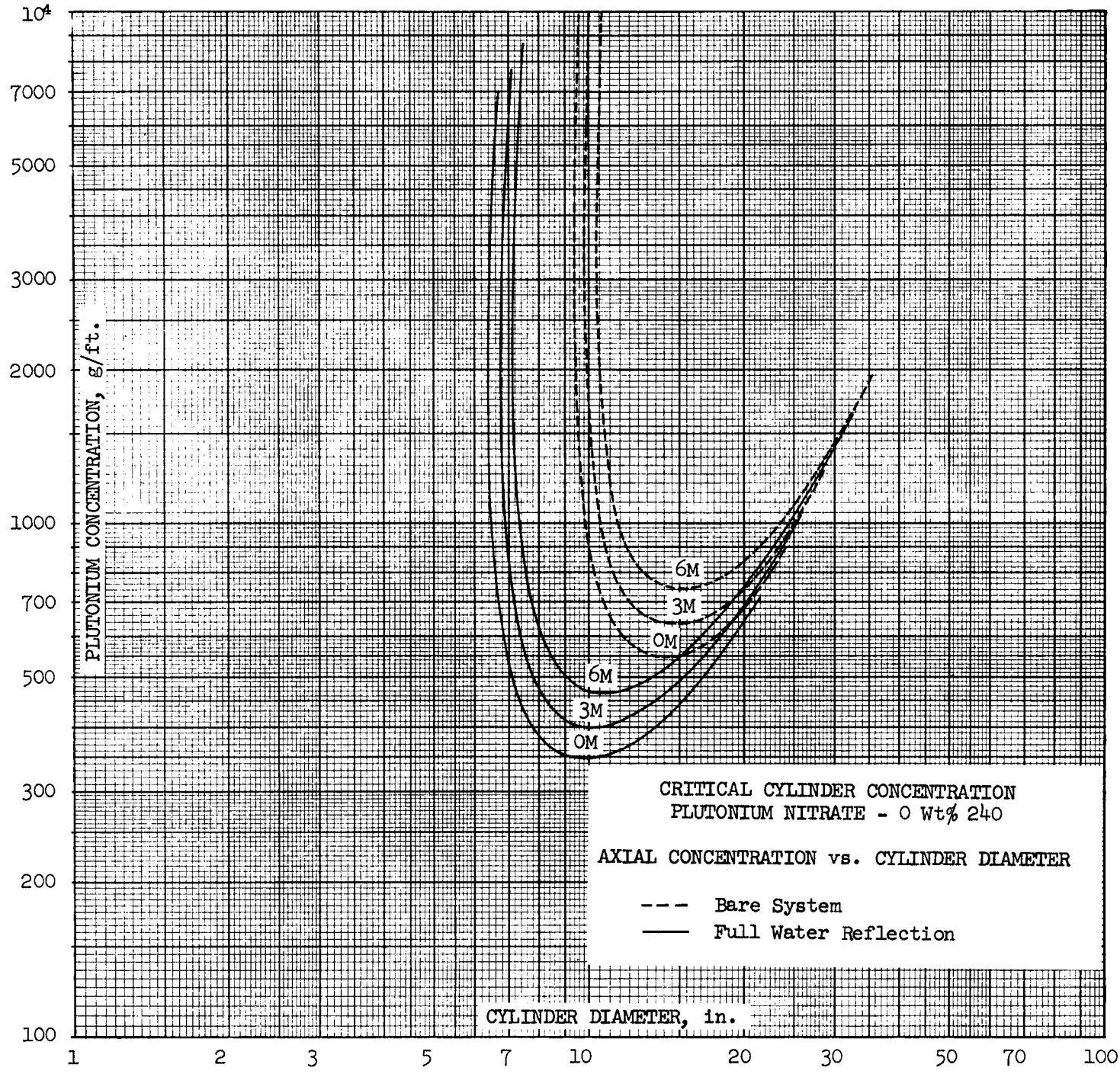

PLUTONIUM CONCENTRATION, g/ft.
10^4
7000
5000
3000
2000
1000
700
500
300
200
100
6M
3M
0M
CRITICAL CYLINDER CONCENTRATION
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 5 Wt% 240
AXIAL CONCENTRATION vs. CYLINDER DIAMETER
CYLINDER DIAMETER, in.
1
2
3
5
7
10
20
30
50
70
100

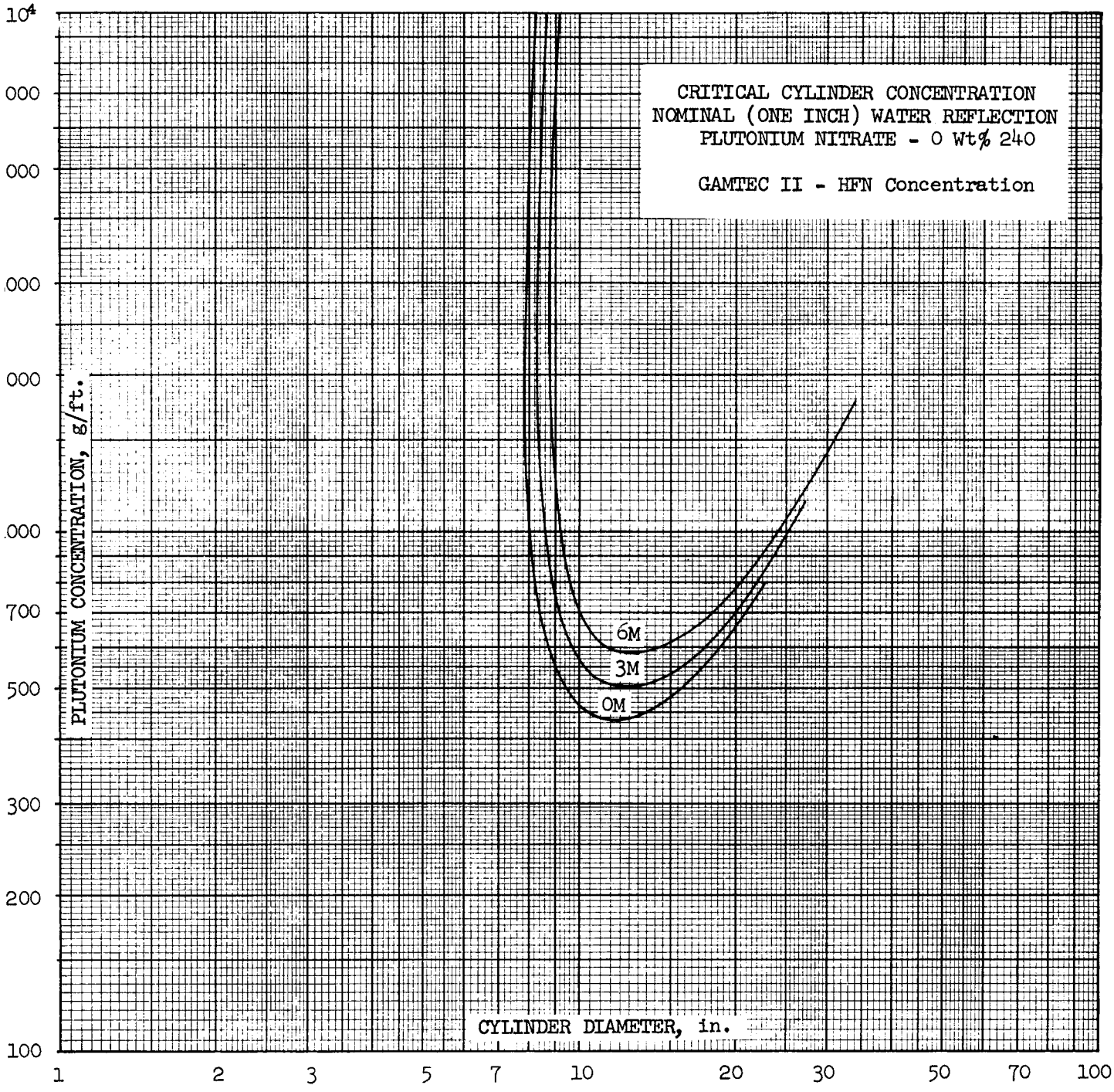

PLUTONIUM CONCENTRATION, g/ft.
10^4
7000
5000
3000
2000
1000
700
500
300
200
100
Unreflected
1" H_2O Reflection
Full H_2O Reflection
CRITICAL CYLINDER CONCENTRATION
PLUTONIUM-H_2O - 5 Wt% 240
AXIAL CONCENTRATION vs. CYLINDER DIAMETER
CYLINDER DIAMETER, in.
1
2
3
5
7
10
20
30
50
70
1

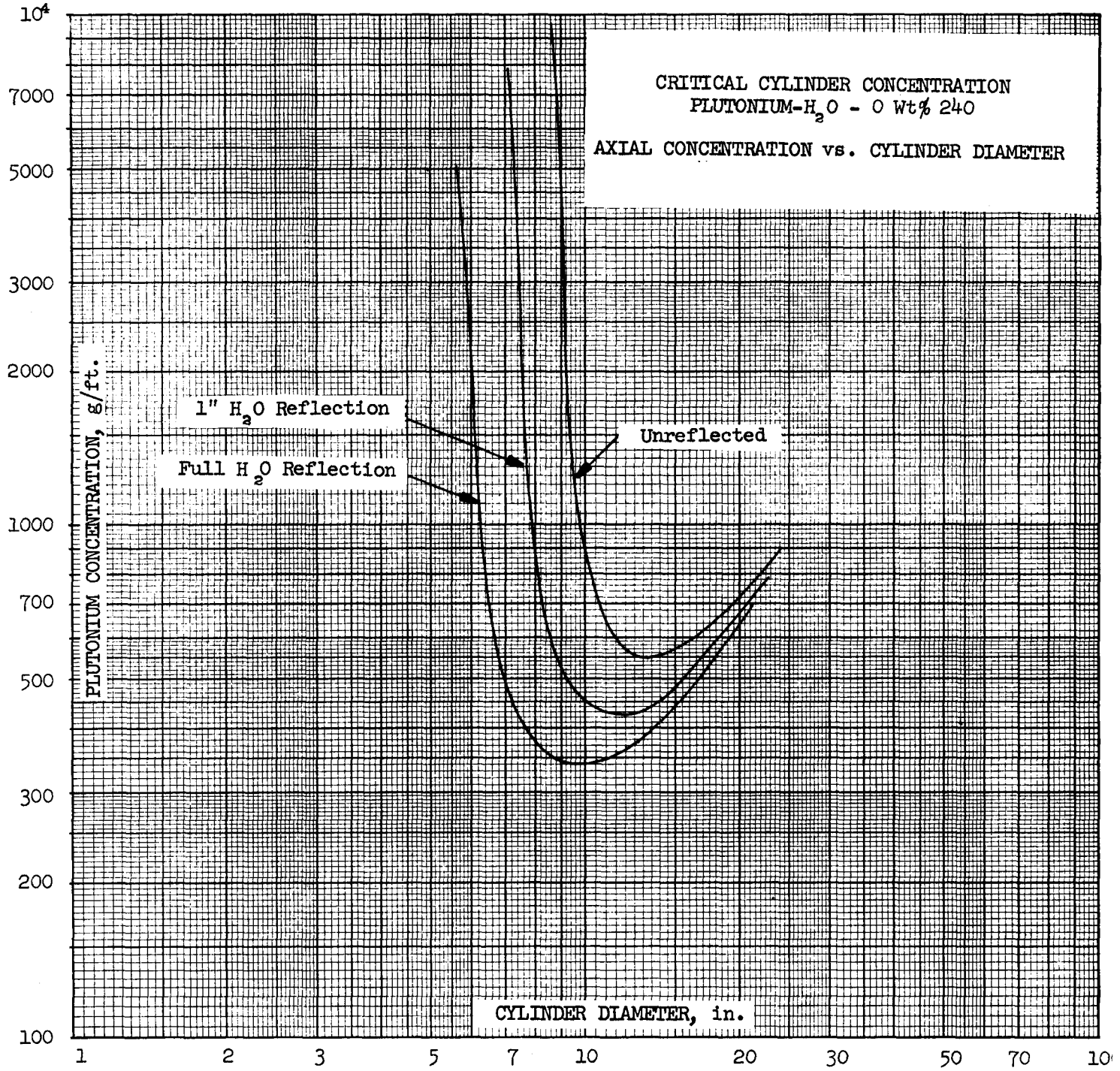

CRITICAL CYLINDER CONCENTRATION
PLUTONIUM NITRATE - 3 Wt% 240
AXIAL CONCENTRATION vs. CYLINDER DIAMETER
----Bare System
——Full Water Reflection
PLUTONIUM CONCENTRATION, g/ft.
CYLINDER DIAMETER, in.
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100
6M
3M
0M
6M
3M
0M

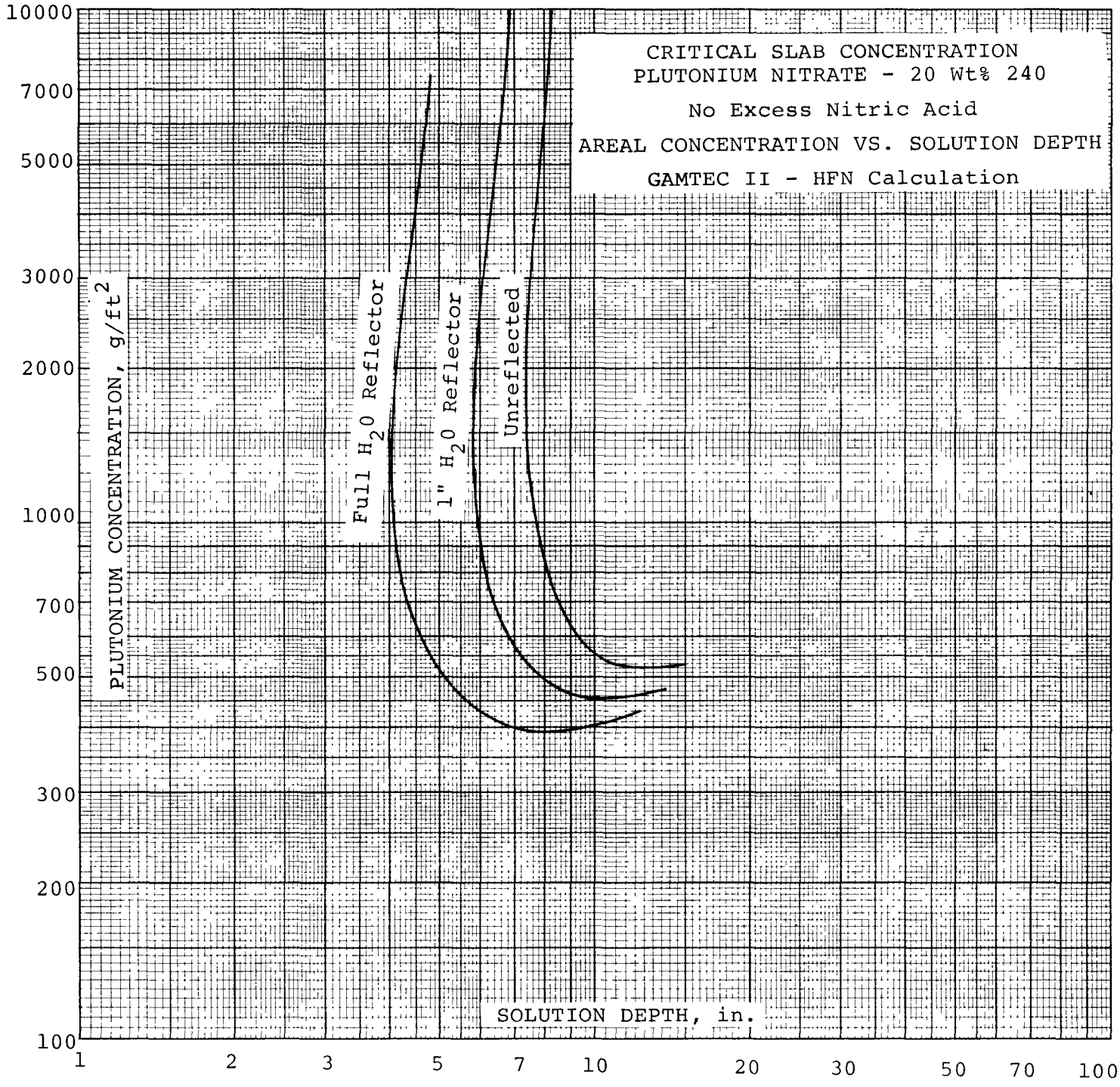

PLUTONIUM CONCENTRATION, g/ft.
CYLINDER DIAMETER, in.
6M
3M
0M
CRITICAL CYLINDER CONCENTRATION
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-II - HFN CALCULATION

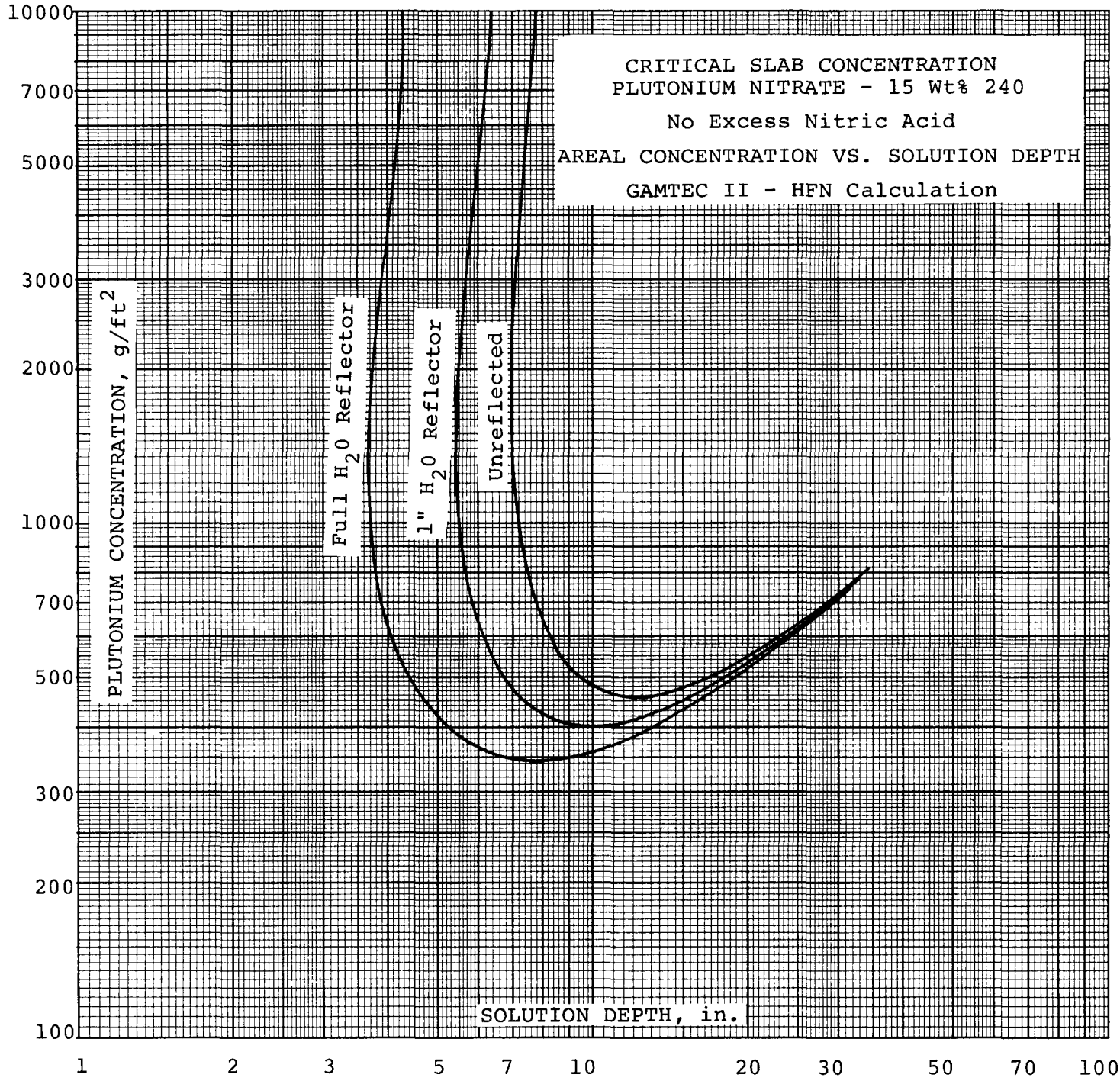

PLUTONIUM CONCENTRATION, g/ft.
10^4
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100
CYLINDER DIAMETER, in.
Unreflected
1" H_2O Reflection
Full H_2O Reflection
CRITICAL CYLINDER CONCENTRATION
PLUTONIUM-H_2O - 3 Wt% 240
AXIAL CONCENTRATION vs. CYLINDER DIAMETER

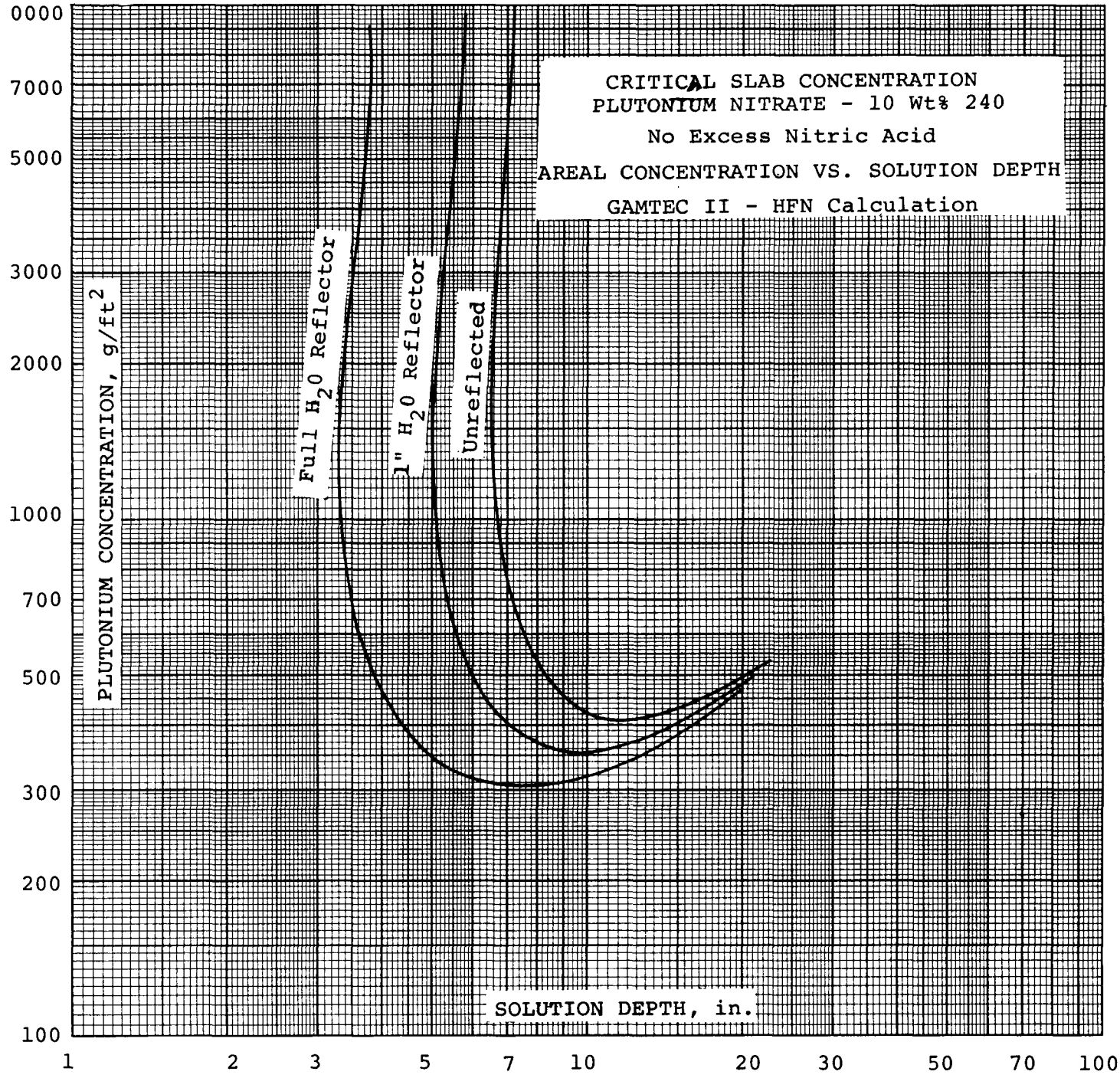

PLUTONIUM CONCENTRATION, g/ft.
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100
CYLINDER DIAMETER, in.
6M
3M
0M
6M
3M
0M
CRITICAL CYLINDER CONCENTRATION
PLUTONIUM NITRATE - 0 Wt% 240
AXIAL CONCENTRATION vs. CYLINDER DIAMETER
--- Bare System
—— Full Water Reflection

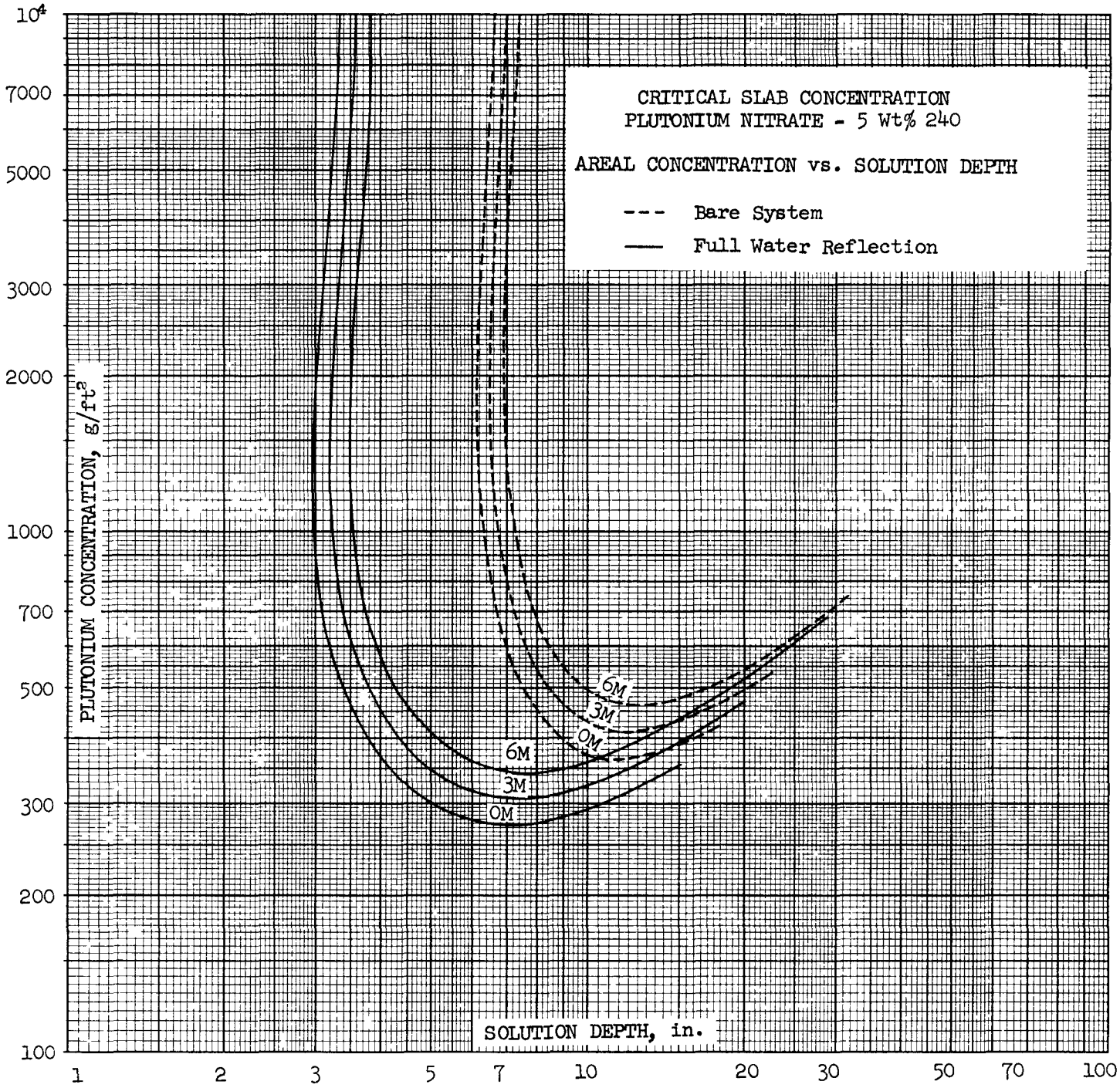

CRITICAL CYLINDER CONCENTRATION
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Concentration
PLUTONIUM CONCENTRATION, g/ft.
CYLINDER DIAMETER, in.
6M
3M
0M
10⁴
000
000
000
000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100

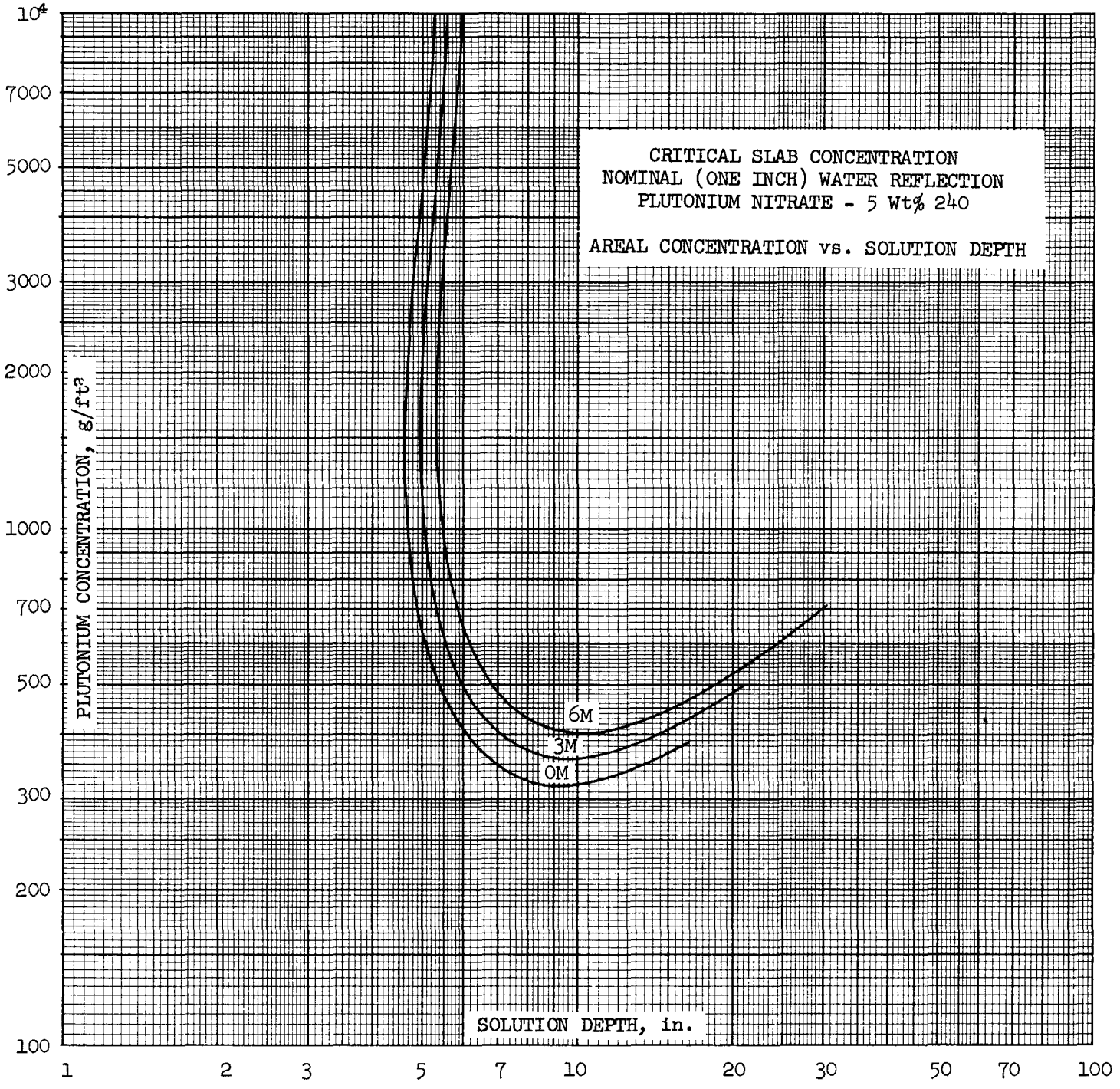

CRITICAL CYLINDER CONCENTRATION
PLUTONIUM-H2O - 0 Wt% 240
AXIAL CONCENTRATION vs. CYLINDER DIAMETER
PLUTONIUM CONCENTRATION, g/ft.
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1" H2O Reflection
Full H2O Reflection
Unreflected
CYLINDER DIAMETER, in.
1
2
3
5
7
10
20
30
50
70

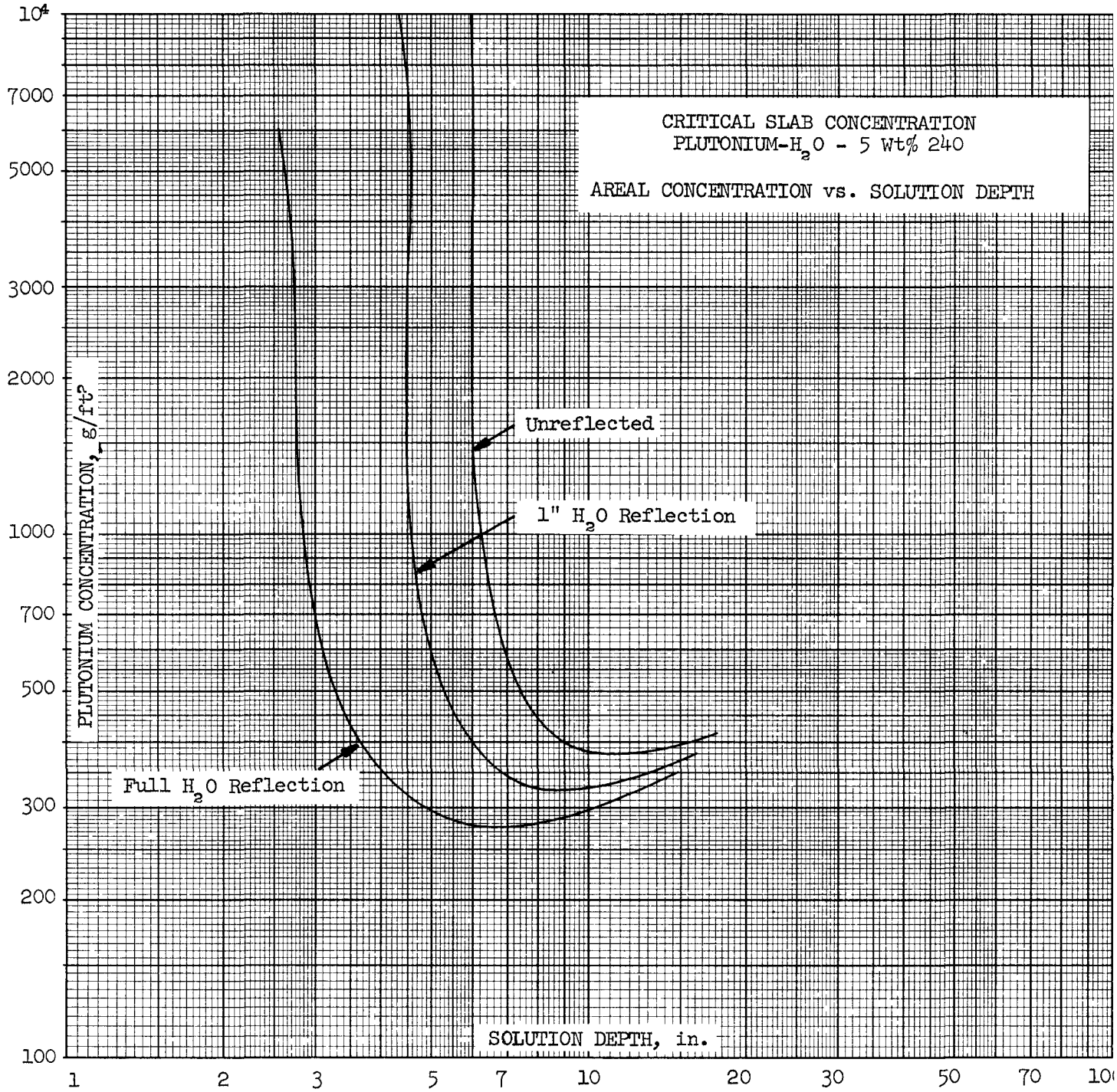

CRITICAL SLAB CONCENTRATION
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
AREAL CONCENTRATION VS. SOLUTION DEPTH
GAMTEC II - HFN Calculation
PLUTONIUM CONCENTRATION, g/ft2
SOLUTION DEPTH, in.
Full H2O Reflector
1" H2O Reflector
Unreflected
10000
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100

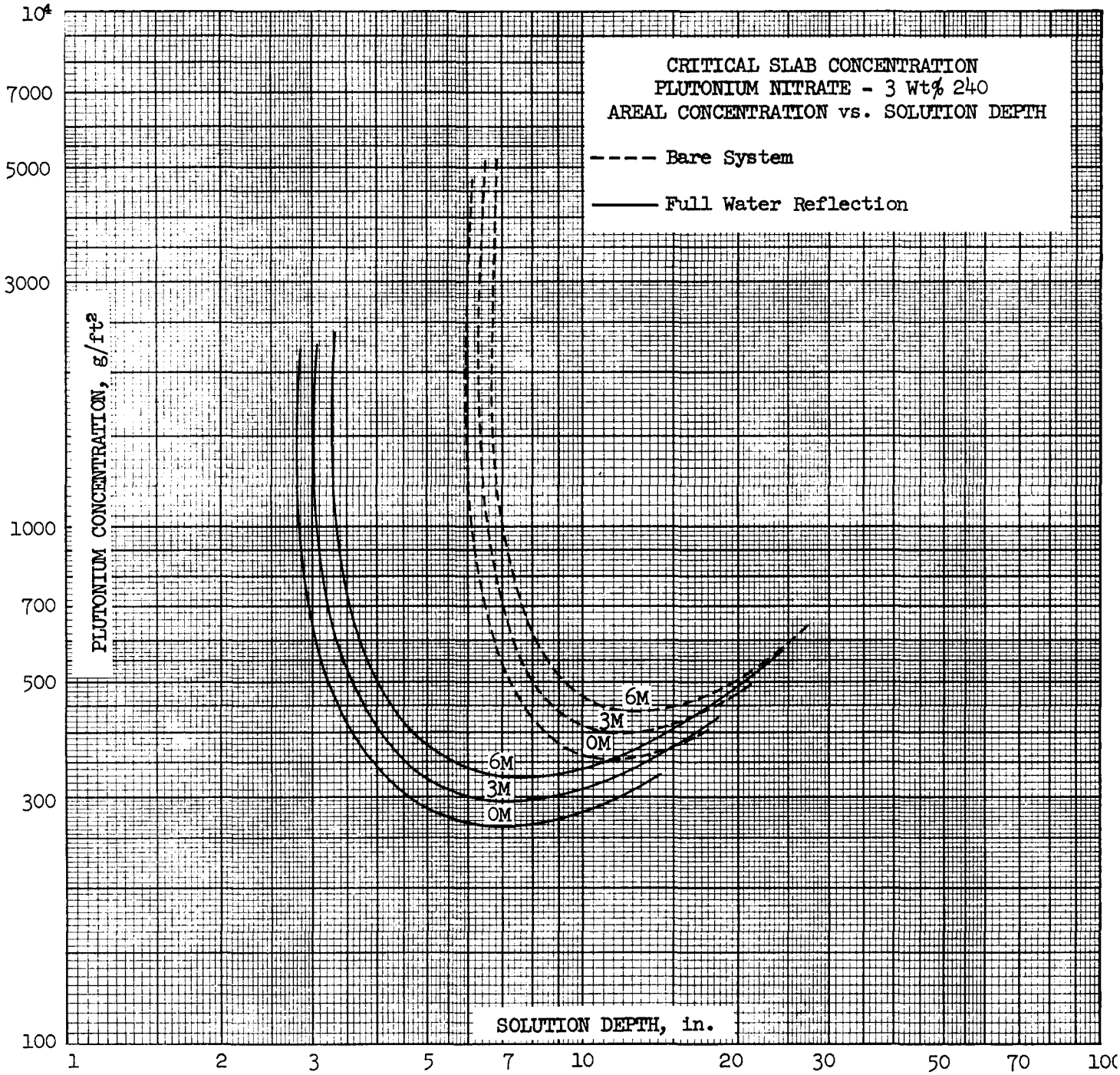

CRITICAL SLAB CONCENTRATION
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
AREAL CONCENTRATION VS. SOLUTION DEPTH
GAMTEC II - HFN Calculation
PLUTONIUM CONCENTRATION, g/ft2
SOLUTION DEPTH, in.
Full H2O Reflector
1" H2O Reflector
Unreflected
10000
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100

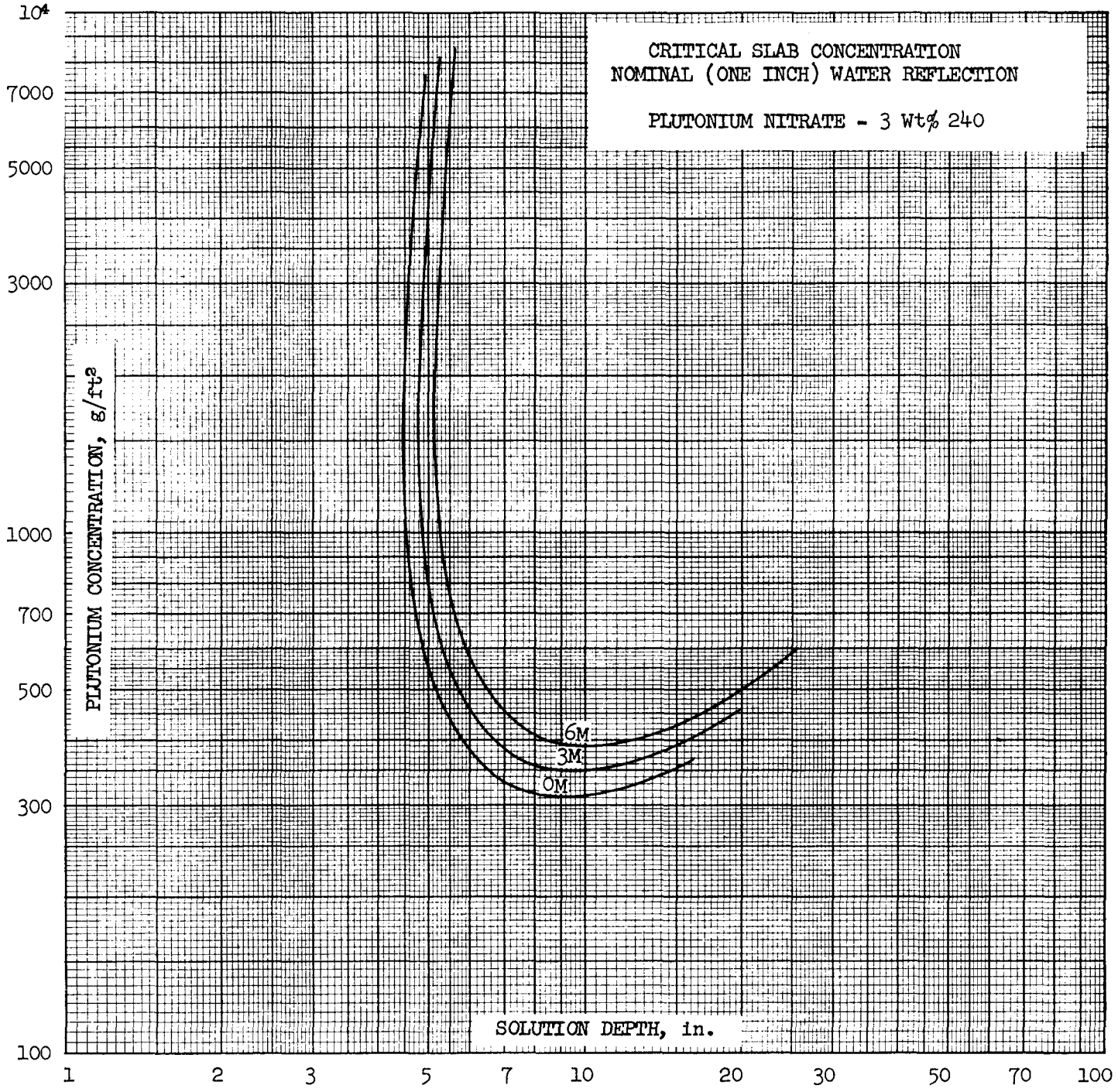

CRITICAL SLAB CONCENTRATION
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
AREAL CONCENTRATION VS. SOLUTION DEPTH
GAMTEC II - HFN Calculation
PLUTONIUM CONCENTRATION, g/ft2
SOLUTION DEPTH, in.
Full H2O Reflector
1" H2O Reflector
Unreflected
0000
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100

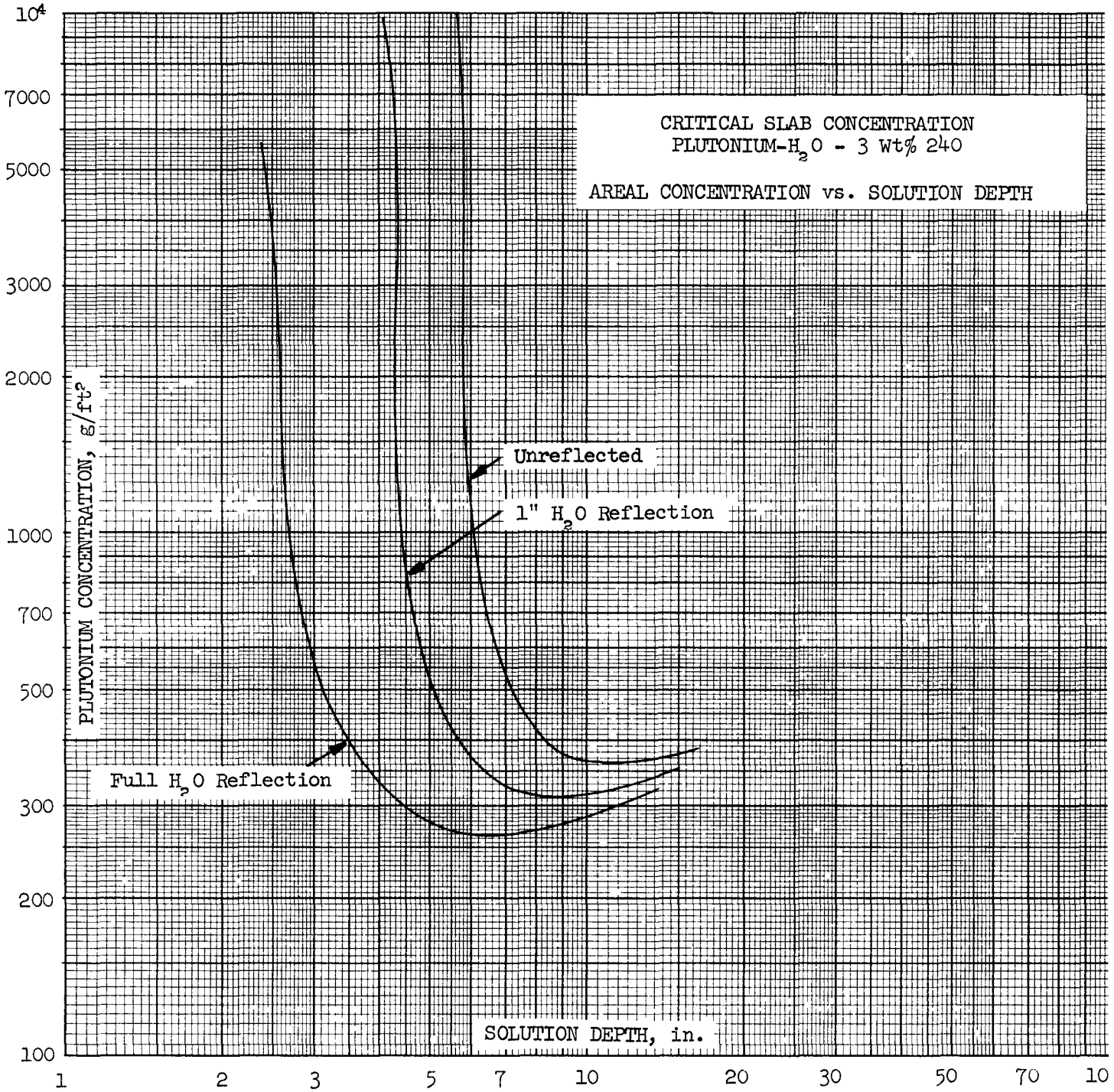

CRITICAL SLAB CONCENTRATION
PLUTONIUM NITRATE - 5 Wt% 240
AREAL CONCENTRATION vs. SOLUTION DEPTH
--- Bare System
—— Full Water Reflection
PLUTONIUM CONCENTRATION, g/ft²
SOLUTION DEPTH, in.
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100
6M
3M
0M
6M
3M
0M

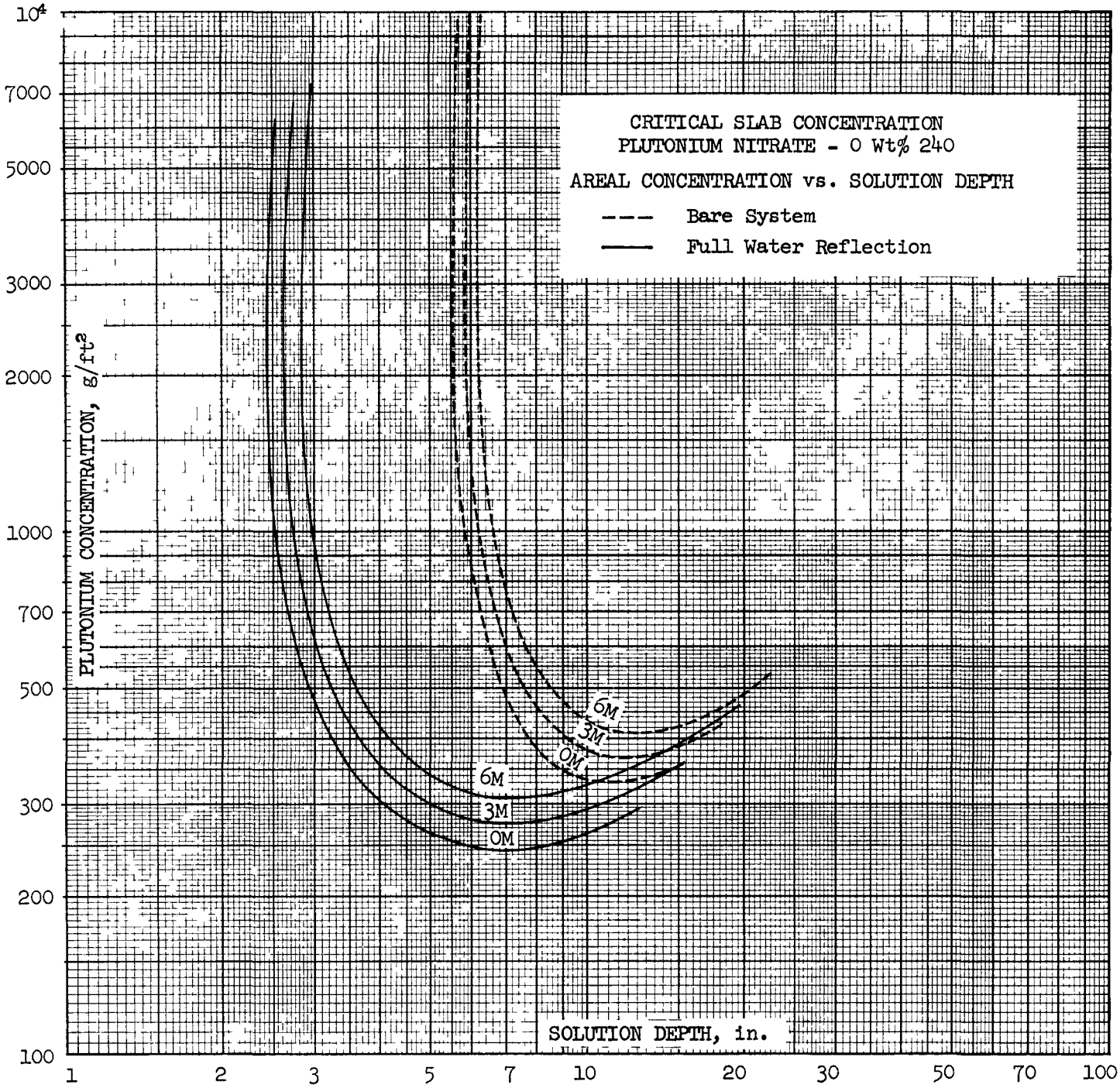

CRITICAL SLAB CONCENTRATION
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 5 Wt% 240
AREAL CONCENTRATION vs. SOLUTION DEPTH
PLUTONIUM CONCENTRATION, g/ft²
SOLUTION DEPTH, in.
6M
3M
0M
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100

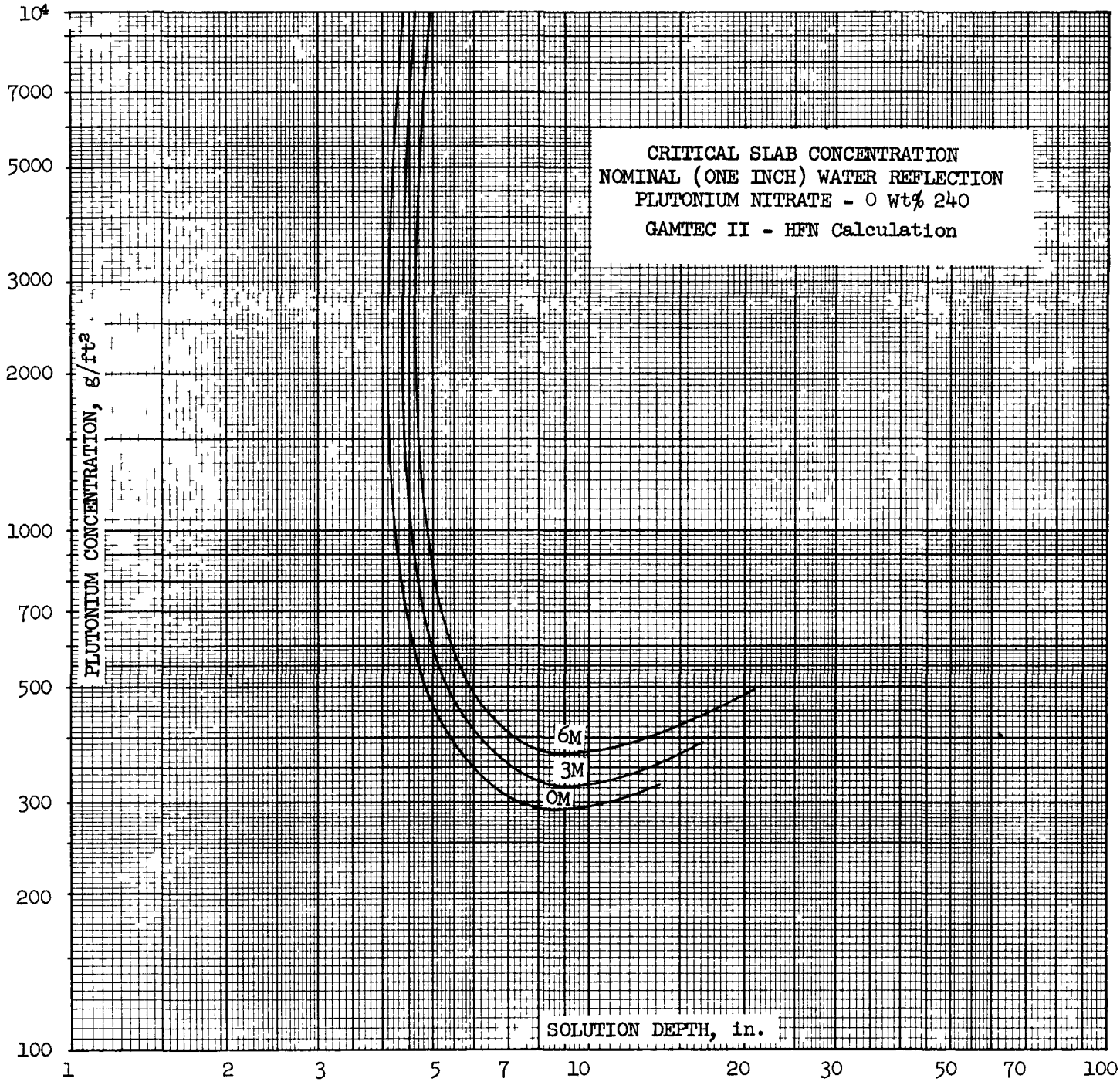

CRITICAL SLAB CONCENTRATION
PLUTONIUM-H2O - 5 Wt% 240
AREAL CONCENTRATION vs. SOLUTION DEPTH
PLUTONIUM CONCENTRATION, g/ft²
SOLUTION DEPTH, in.
Unreflected
1" H2O Reflection
Full H2O Reflection
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70

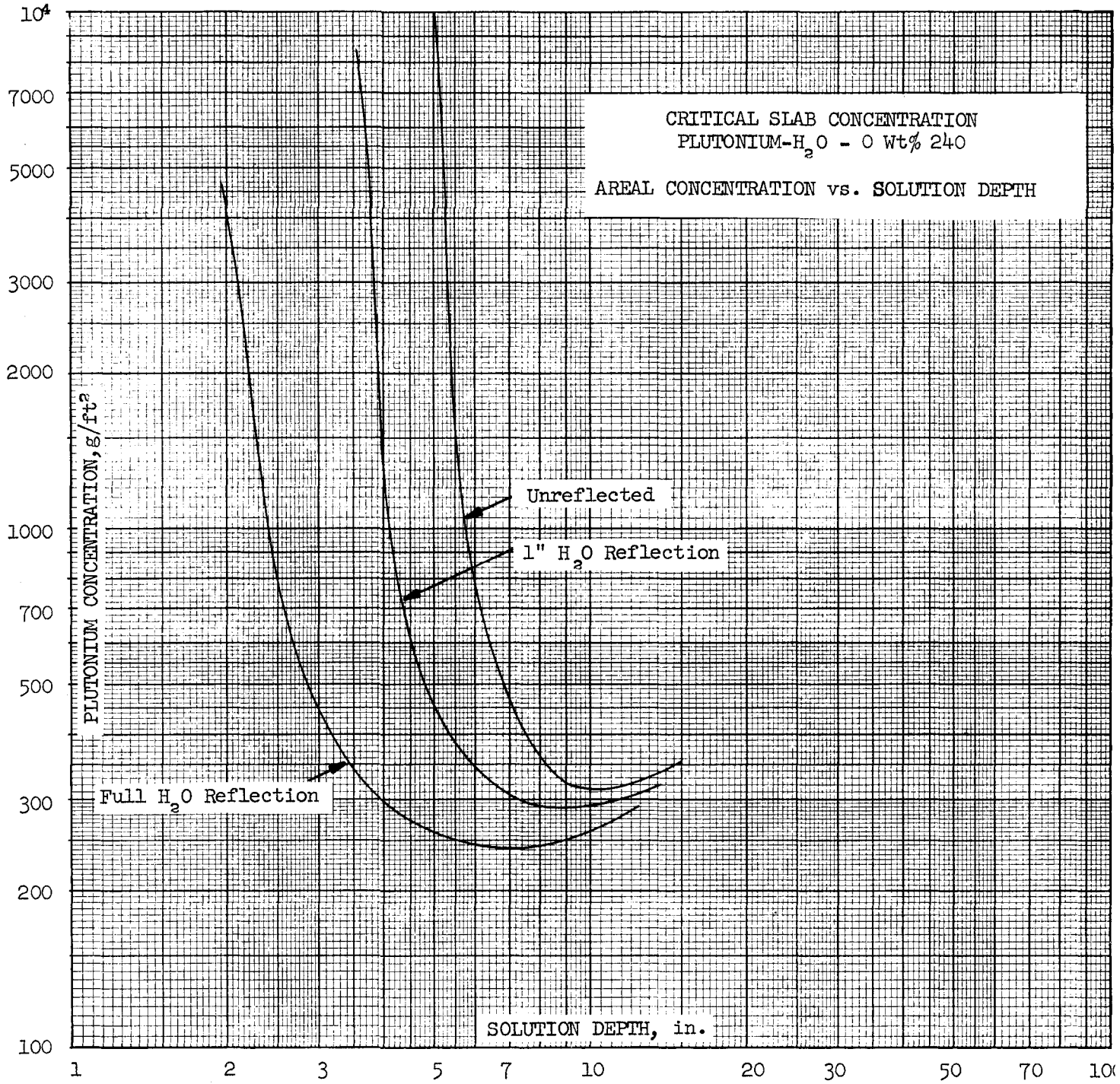

CRITICAL SLAB CONCENTRATION
PLUTONIUM NITRATE - 3 Wt% 240
AREAL CONCENTRATION vs. SOLUTION DEPTH
---- Bare System
——— Full Water Reflection
PLUTONIUM CONCENTRATION, g/ft²
SOLUTION DEPTH, in.
10⁴
7000
5000
3000
1000
700
500
300
100
1
2
3
5
7
10
20
30
50
70
100
6M
3M
0M
6M
3M
0M

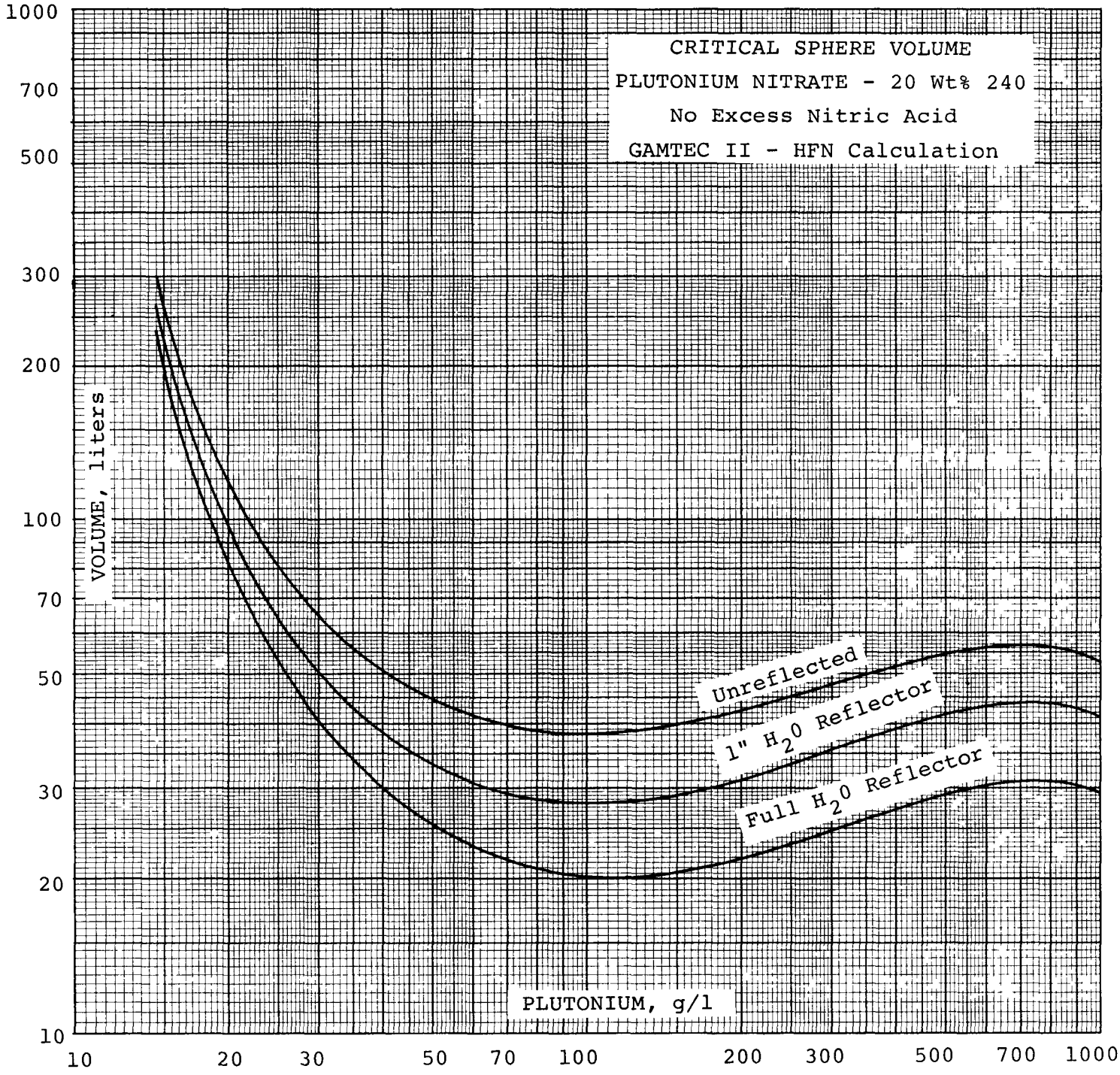

CRITICAL SLAB CONCENTRATION
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 3 Wt% 240
PLUTONIUM CONCENTRATION, g/ft³
SOLUTION DEPTH, in.
6M
3M
0M
10⁴
7000
5000
3000
1000
700
500
300
100
1
2
3
5
7
10
20
30
50
70
100

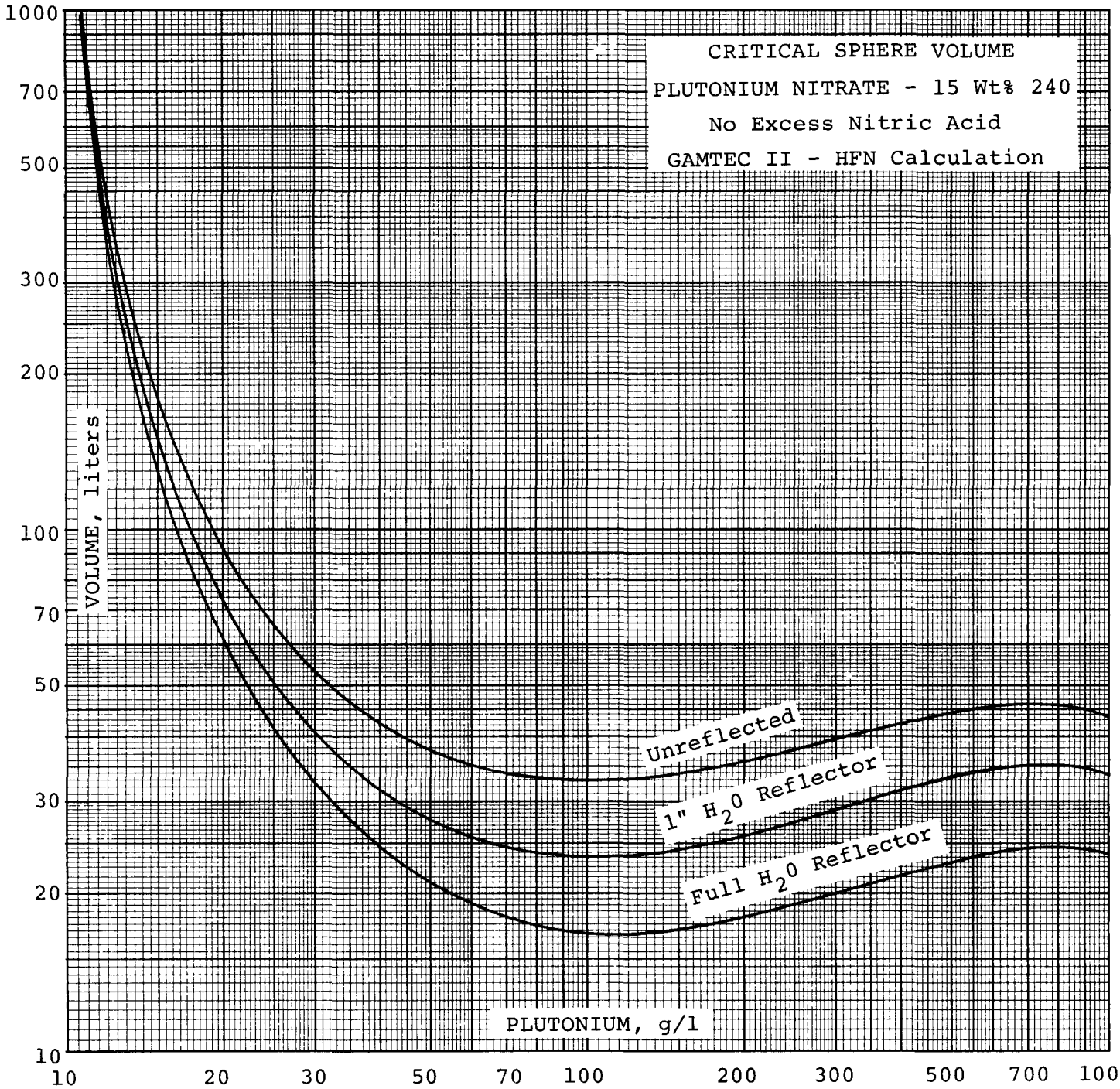

CRITICAL SLAB CONCENTRATION
PLUTONIUM-H2O - 3 Wt% 240
AREAL CONCENTRATION vs. SOLUTION DEPTH
PLUTONIUM CONCENTRATION, g/ft²
SOLUTION DEPTH, in.
Unreflected
1" H2O Reflection
Full H2O Reflection
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70

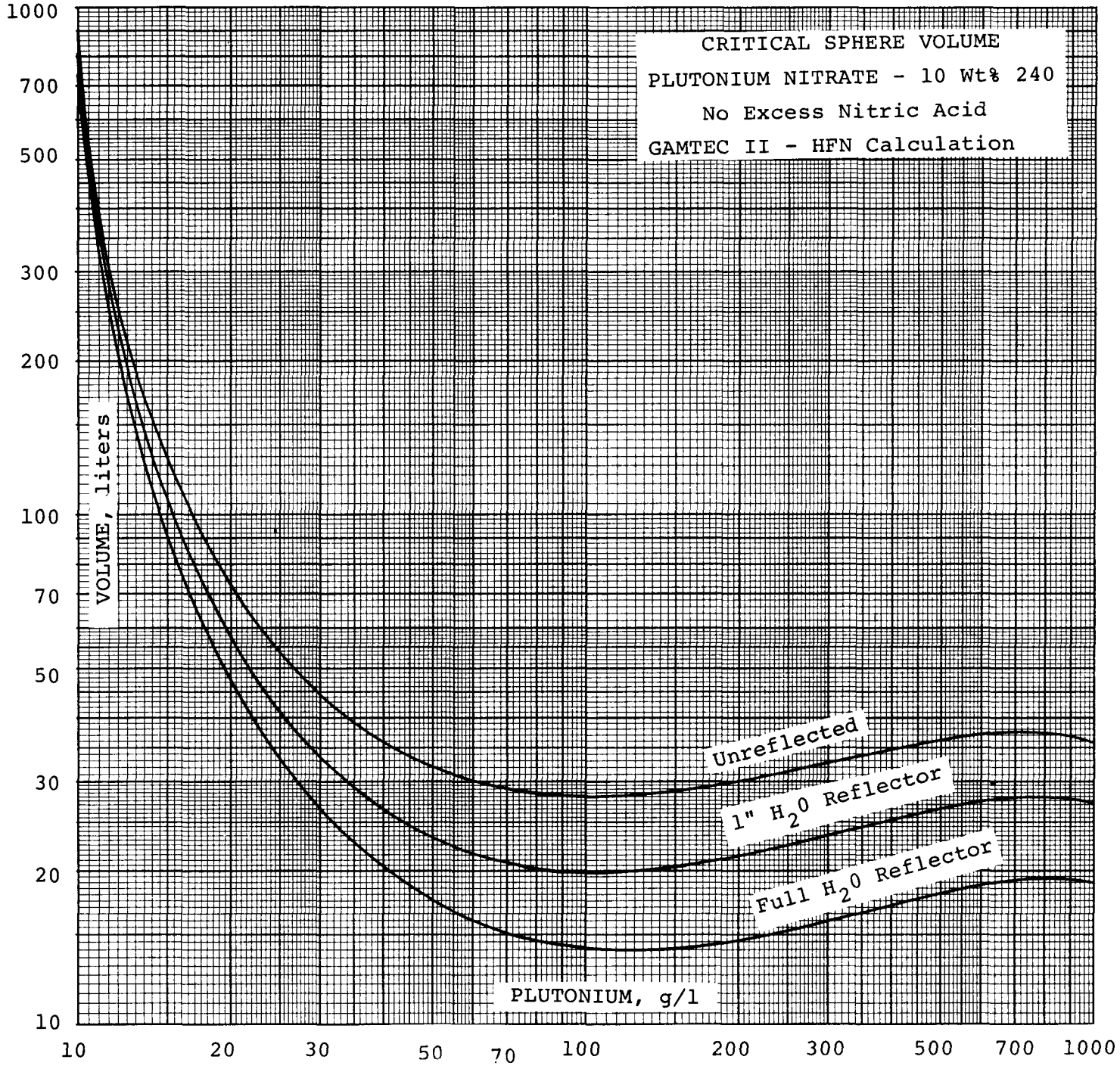

CRITICAL SLAB CONCENTRATION
PLUTONIUM NITRATE - 0 Wt% 240
AREAL CONCENTRATION vs. SOLUTION DEPTH
Bare System
Full Water Reflection
PLUTONIUM CONCENTRATION, g/ft²
SOLUTION DEPTH, in.
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100
6M
3M
0M
6M
3M
0M

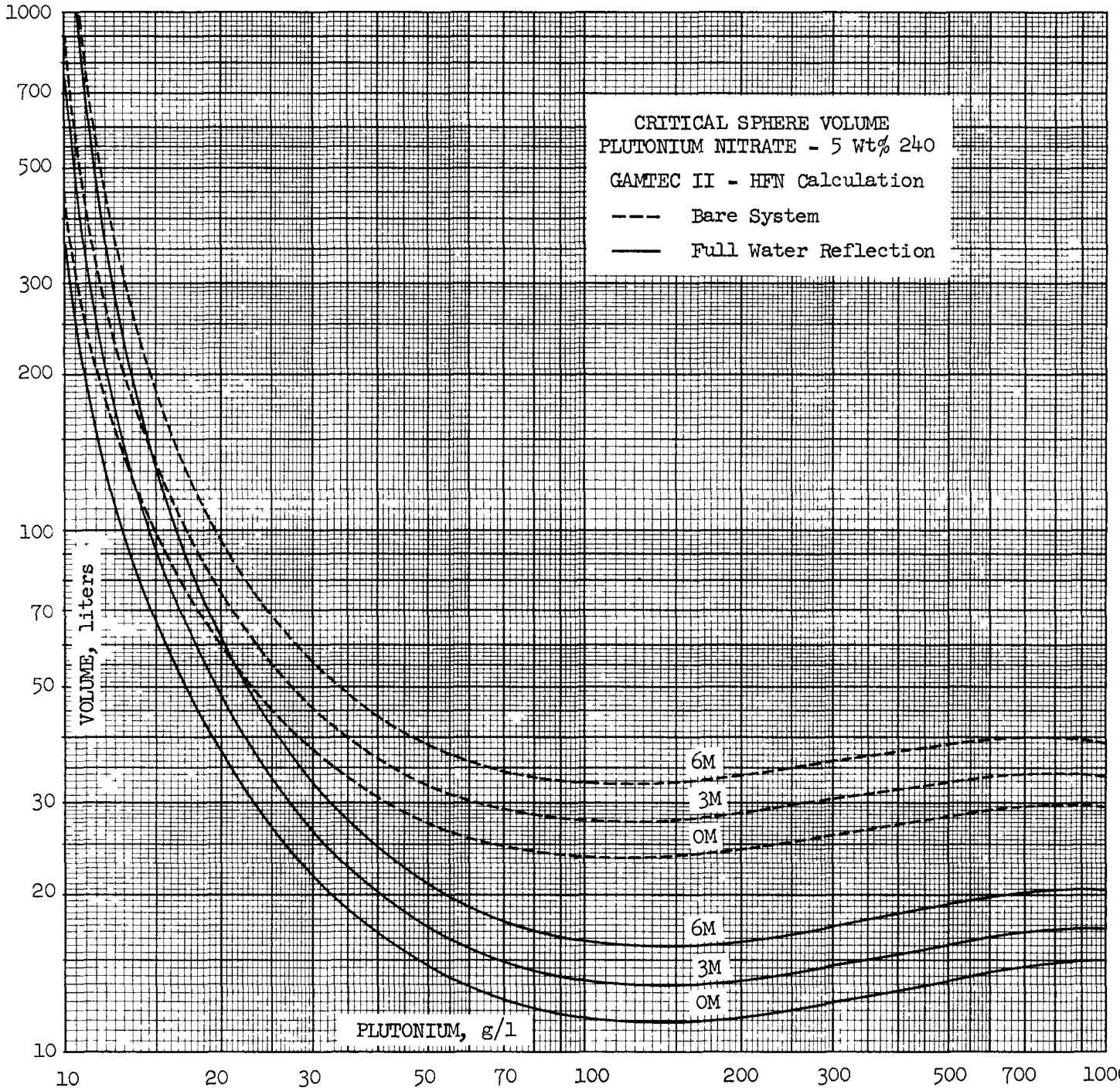

CRITICAL SLAB CONCENTRATION
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Calculation
PLUTONIUM CONCENTRATION, g/ft³
SOLUTION DEPTH, in.
6M
3M
0M
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70
100

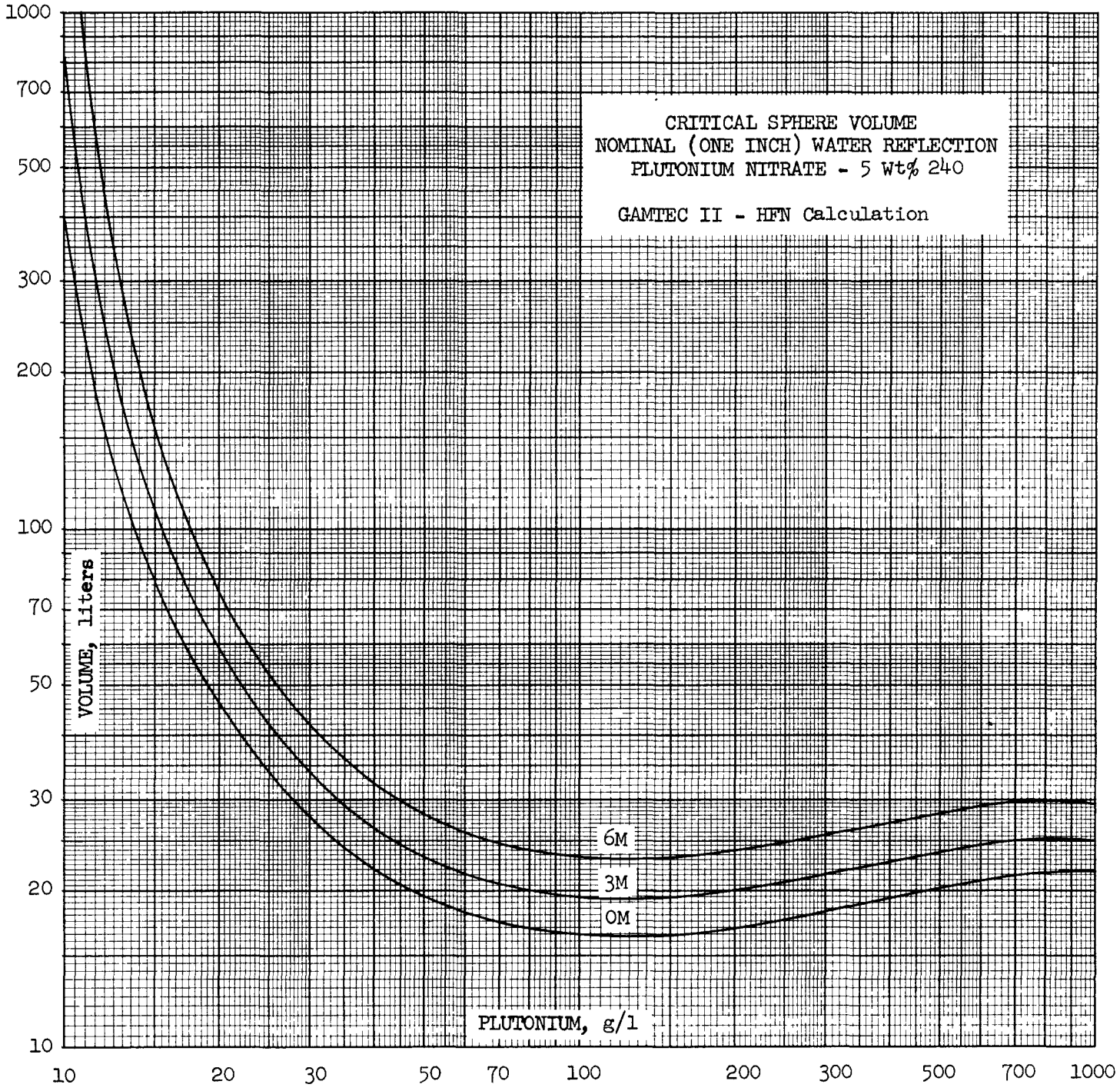

CRITICAL SLAB CONCENTRATION
PLUTONIUM-H2O - 0 Wt% 240
AREAL CONCENTRATION vs. SOLUTION DEPTH
PLUTONIUM CONCENTRATION, g/ft²
SOLUTION DEPTH, in.
Unreflected
1" H2O Reflection
Full H2O Reflection
10⁴
7000
5000
3000
2000
1000
700
500
300
200
100
1
2
3
5
7
10
20
30
50
70

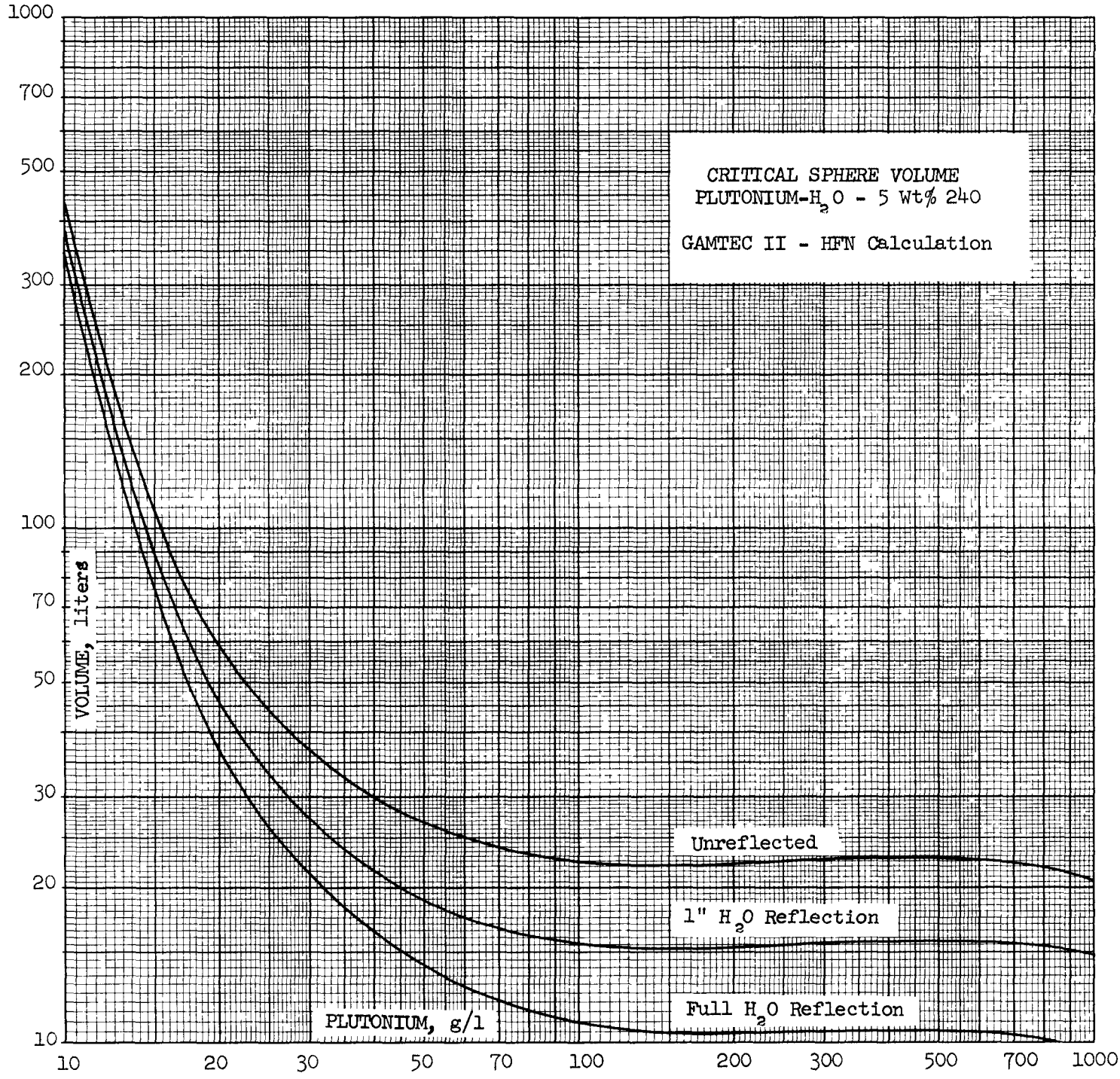

CRITICAL SPHERE VOLUME
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
VOLUME, liters
PLUTONIUM, g/l
Unreflected
1" H_2O Reflector
Full H_2O Reflector
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

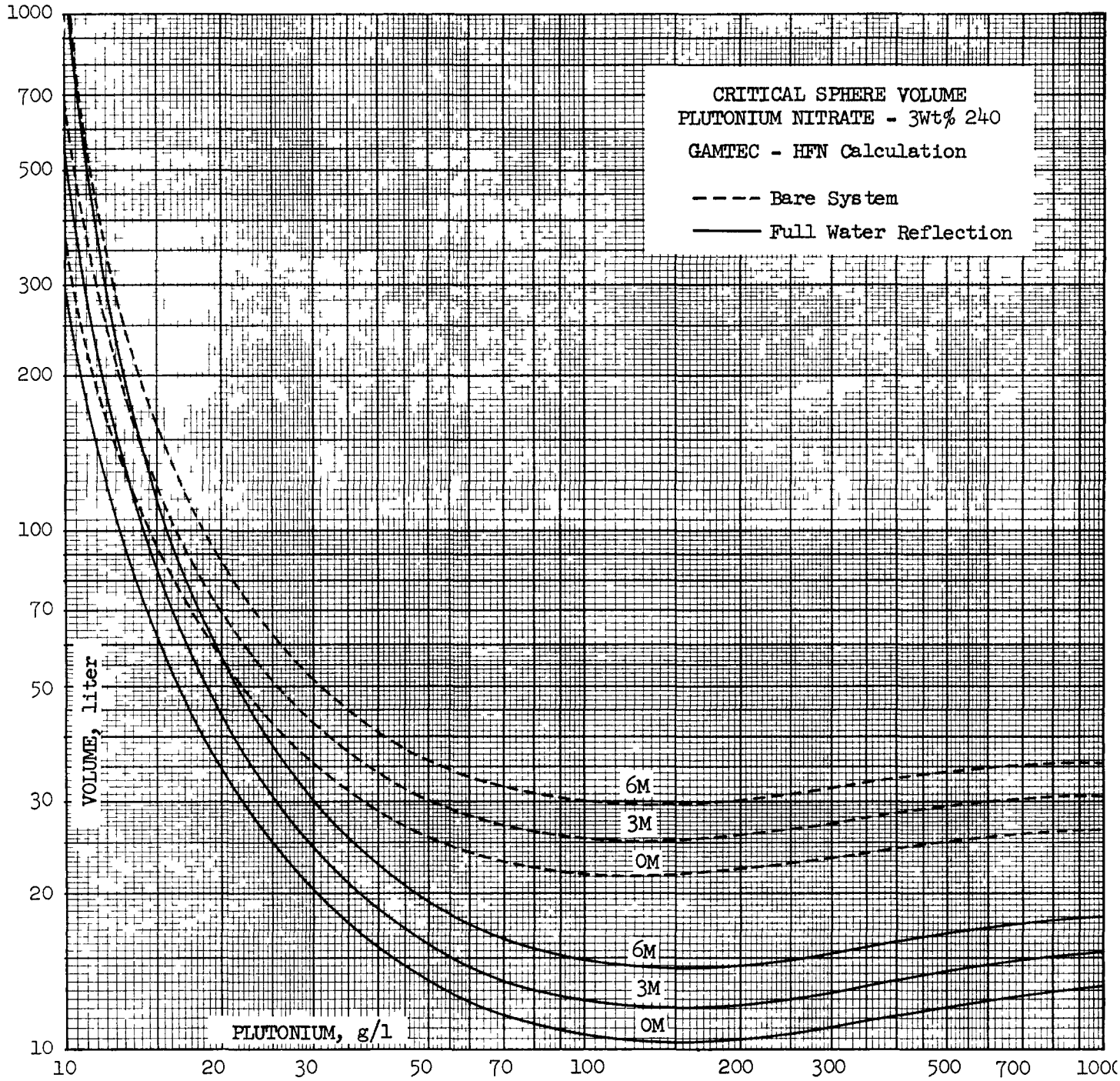

CRITICAL SPHERE VOLUME
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
VOLUME, liters
PLUTONIUM, g/l
Unreflected
1" H_2O Reflector
Full H_2O Reflector
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

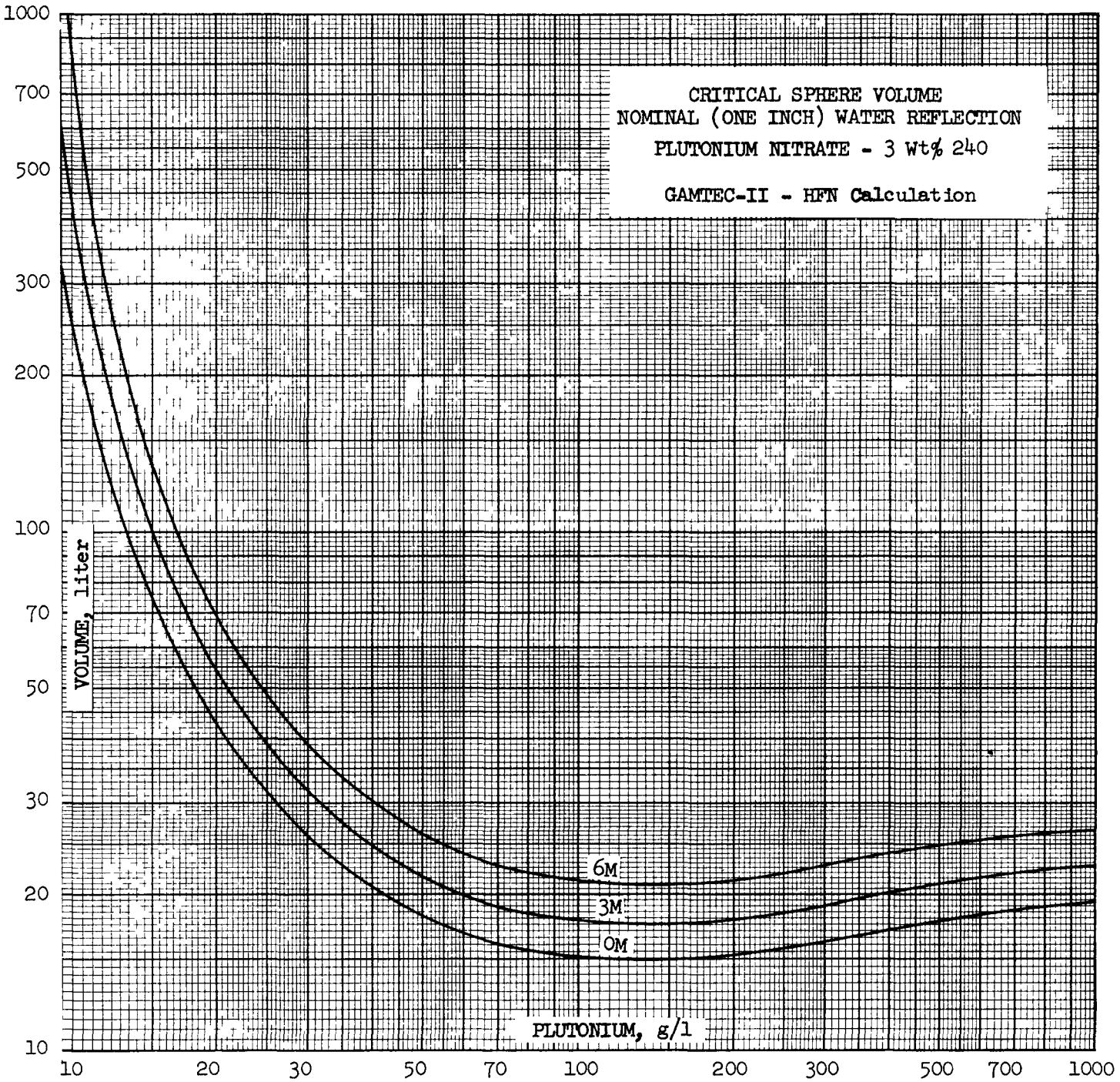

CRITICAL SPHERE VOLUME
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
VOLUME, liters
PLUTONIUM, g/l
Unreflected
1" H_2O Reflector
Full H_2O Reflector
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

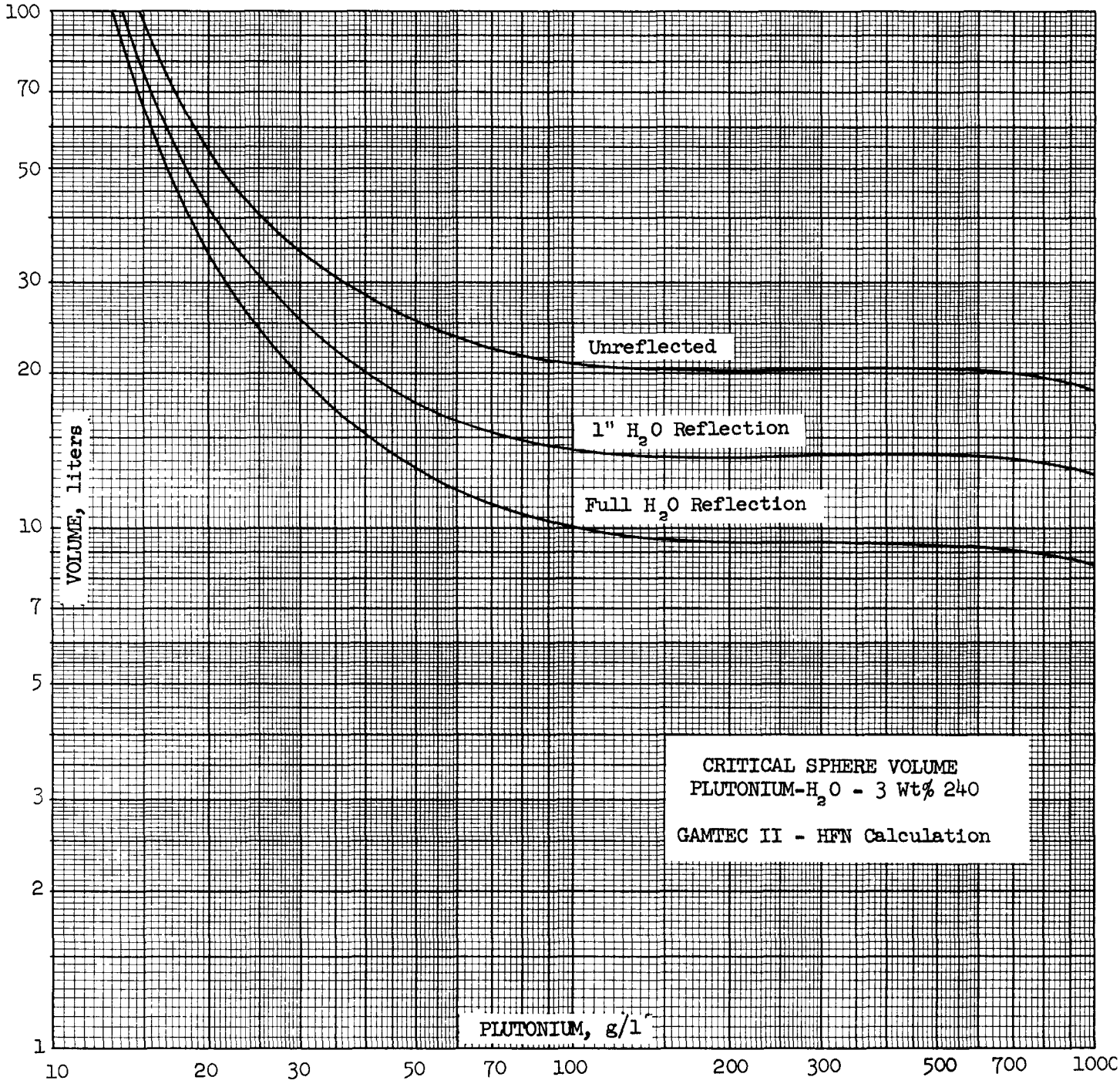

CRITICAL SPHERE VOLUME
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculation
--- Bare System
—— Full Water Reflection
VOLUME, liters
PLUTONIUM, g/l
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000
6M
3M
OM
6M
3M
OM

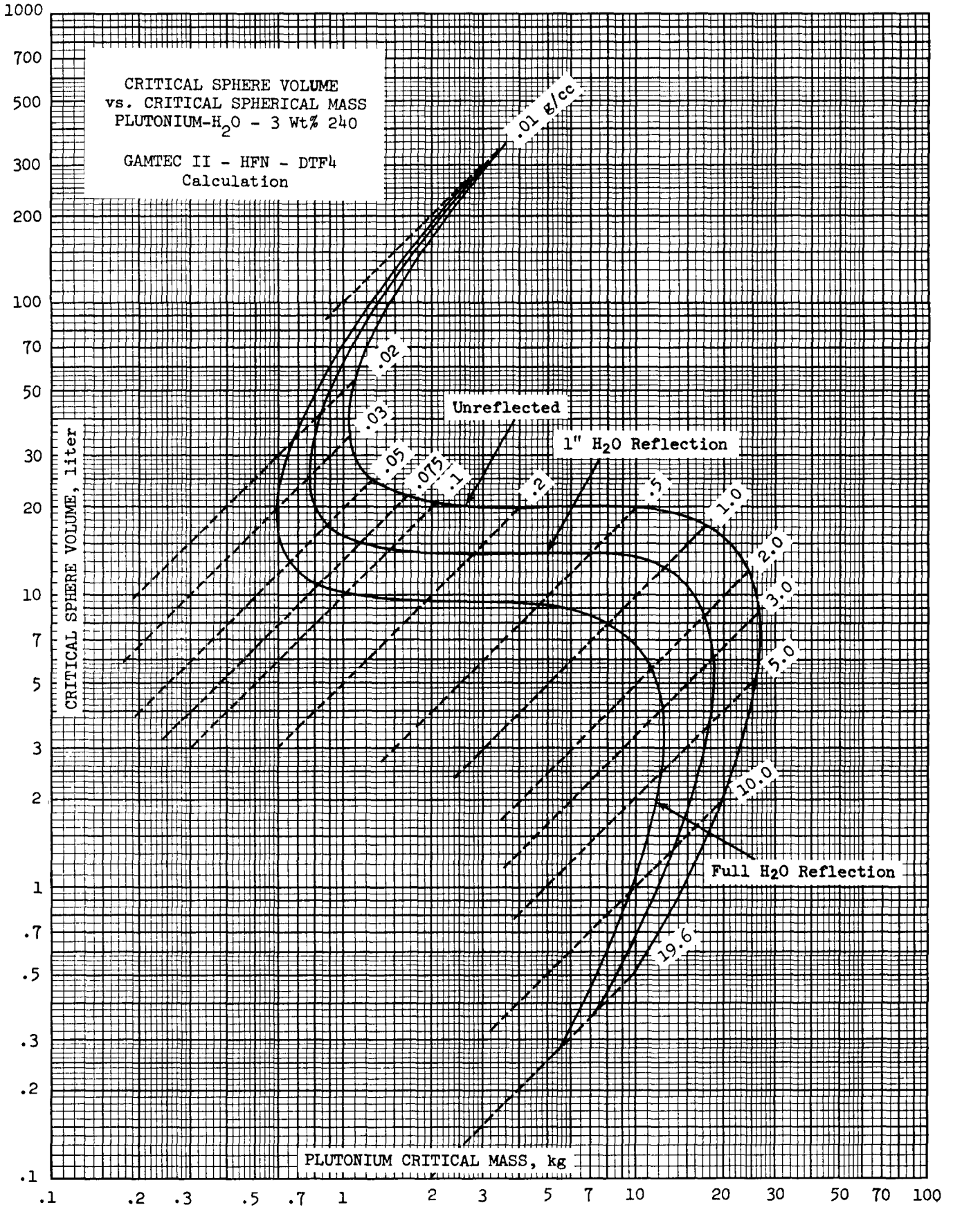

CRITICAL SPHERE VOLUME
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculation
VOLUME, liters
PLUTONIUM, g/l
6M
3M
0M
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

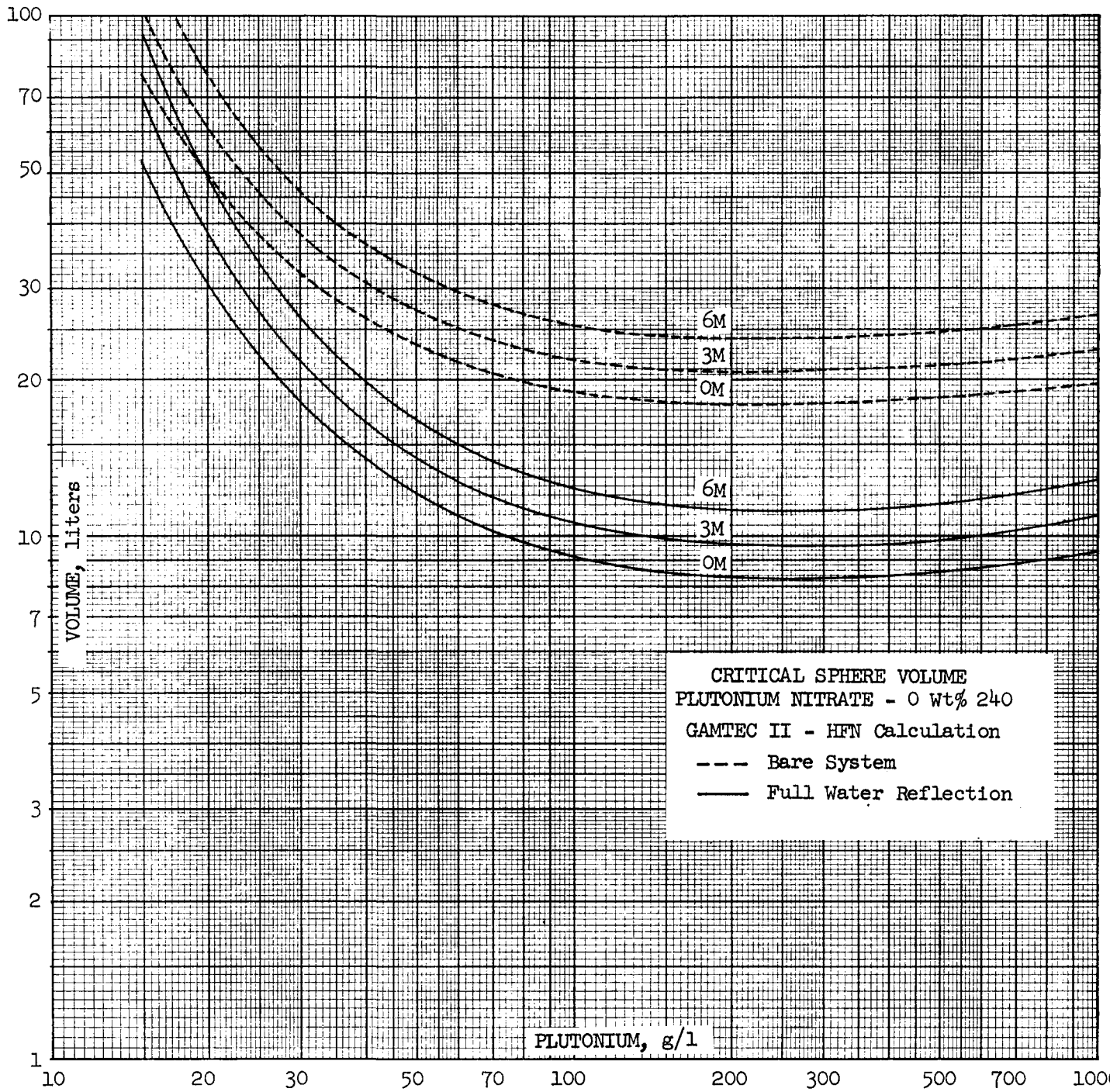

CRITICAL SPHERE VOLUME
PLUTONIUM-H2O - 5 Wt% 240
GAMTEC II - HFN Calculation
VOLUME, liters
PLUTONIUM, g/l
Unreflected
1" H2O Reflection
Full H2O Reflection
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

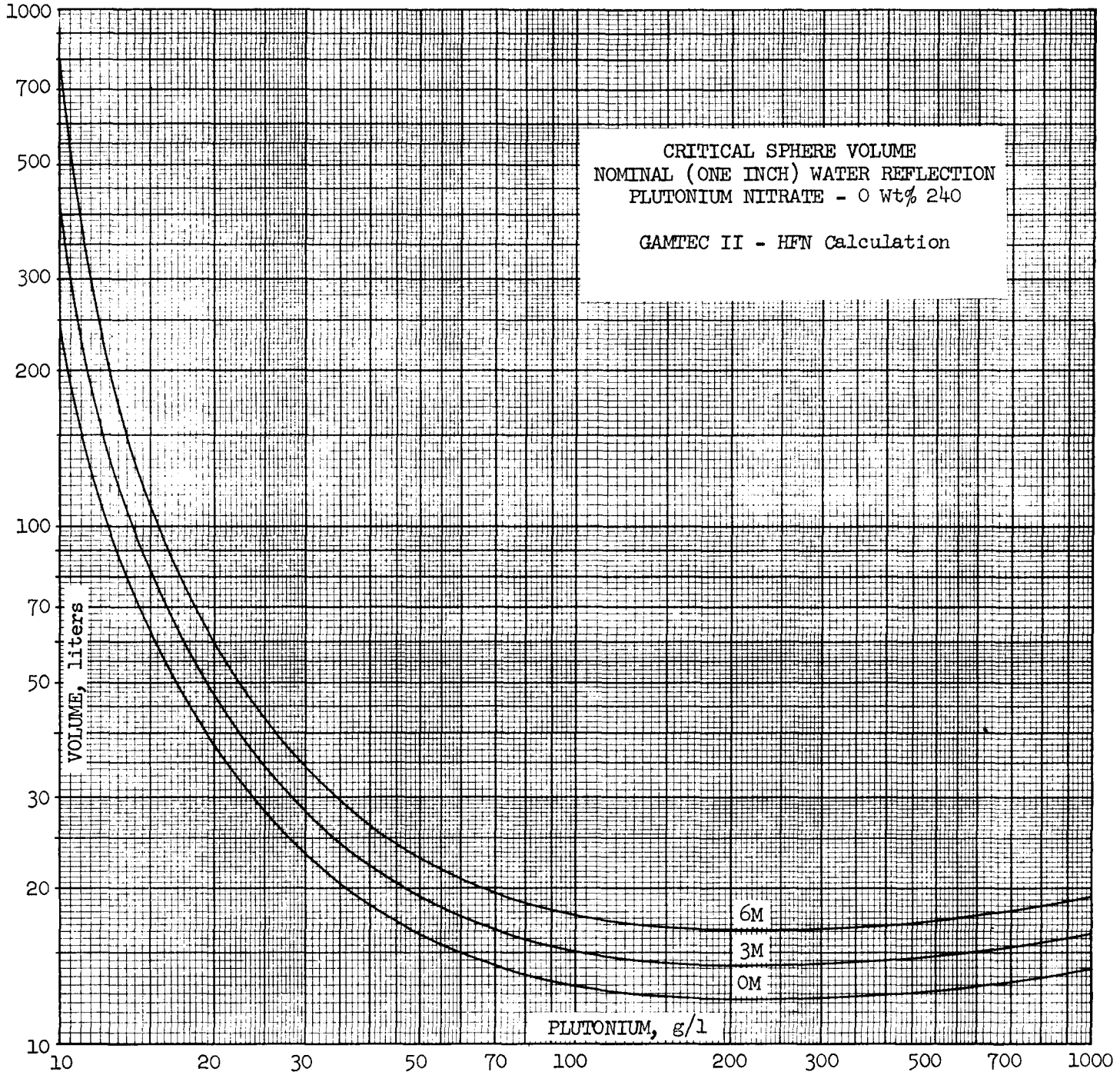

CRITICAL SPHERE VOLUME
PLUTONIUM NITRATE - 3Wt% 240
GAMTEC - HFN Calculation
---- Bare System
——— Full Water Reflection
VOLUME, liter
PLUTONIUM, g/l
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000
6M
3M
0M
6M
3M
0M

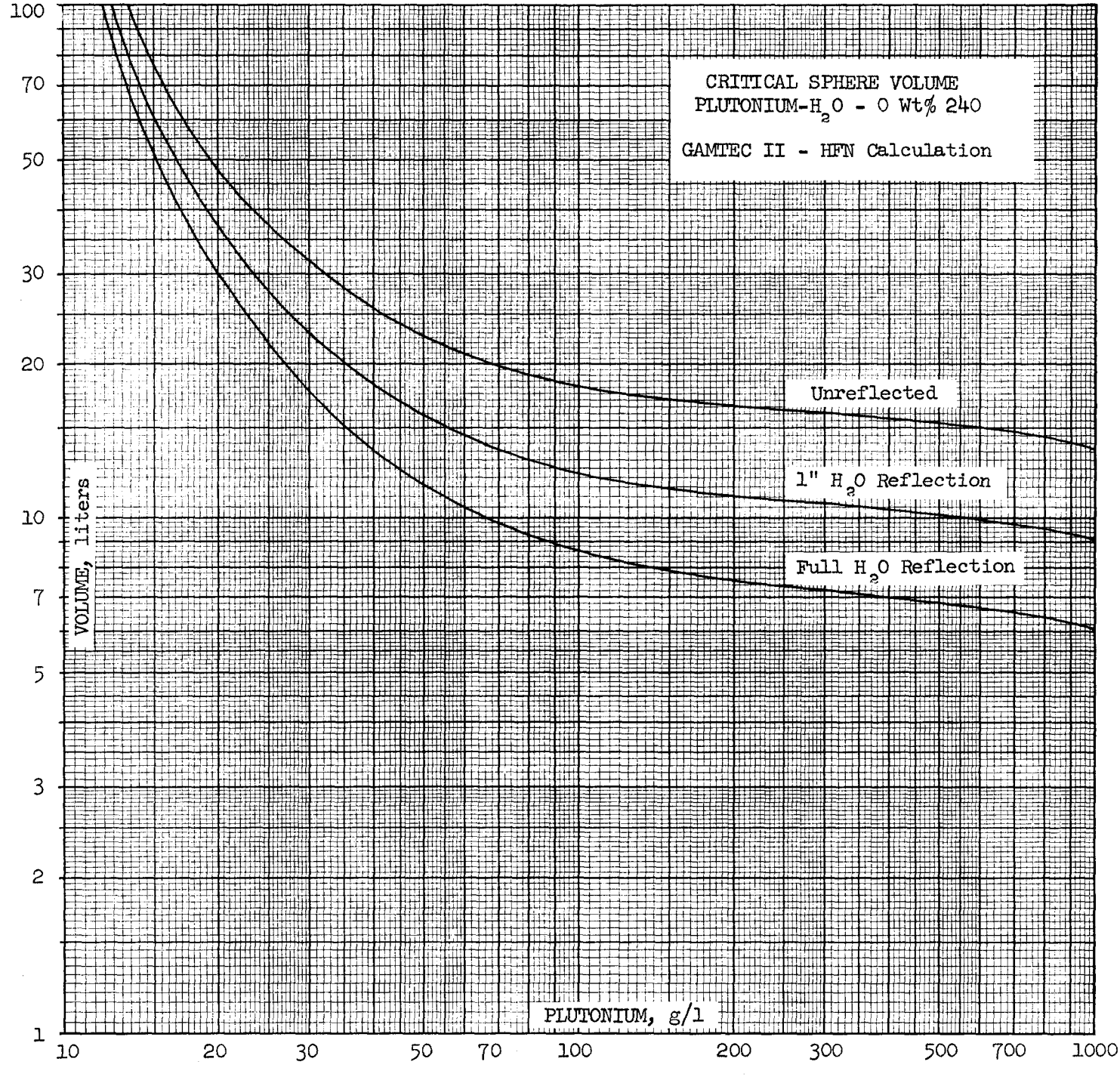

CRITICAL SPHERE VOLUME
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-II - HFN Calculation
VOLUME, liter
PLUTONIUM, g/l
6M
3M
0M
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

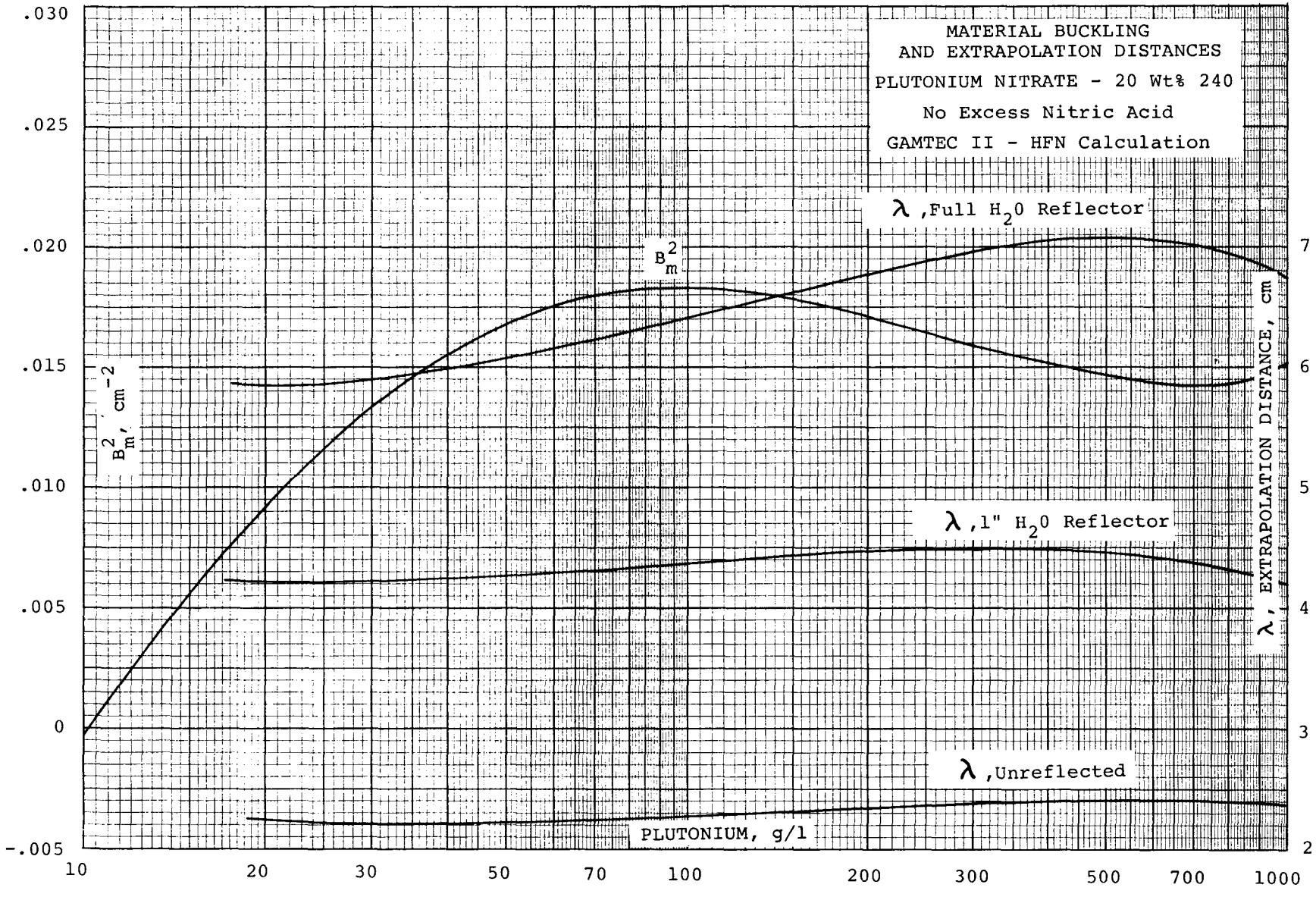

100
70
50
30
20
10
7
5
3
2
1
VOLUME, liters
Unreflected
1" H_2O Reflection
Full H_2O Reflection
CRITICAL SPHERE VOLUME
PLUTONIUM-H_2O - 3 Wt% 240
GAMTEC II - HFN Calculation
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

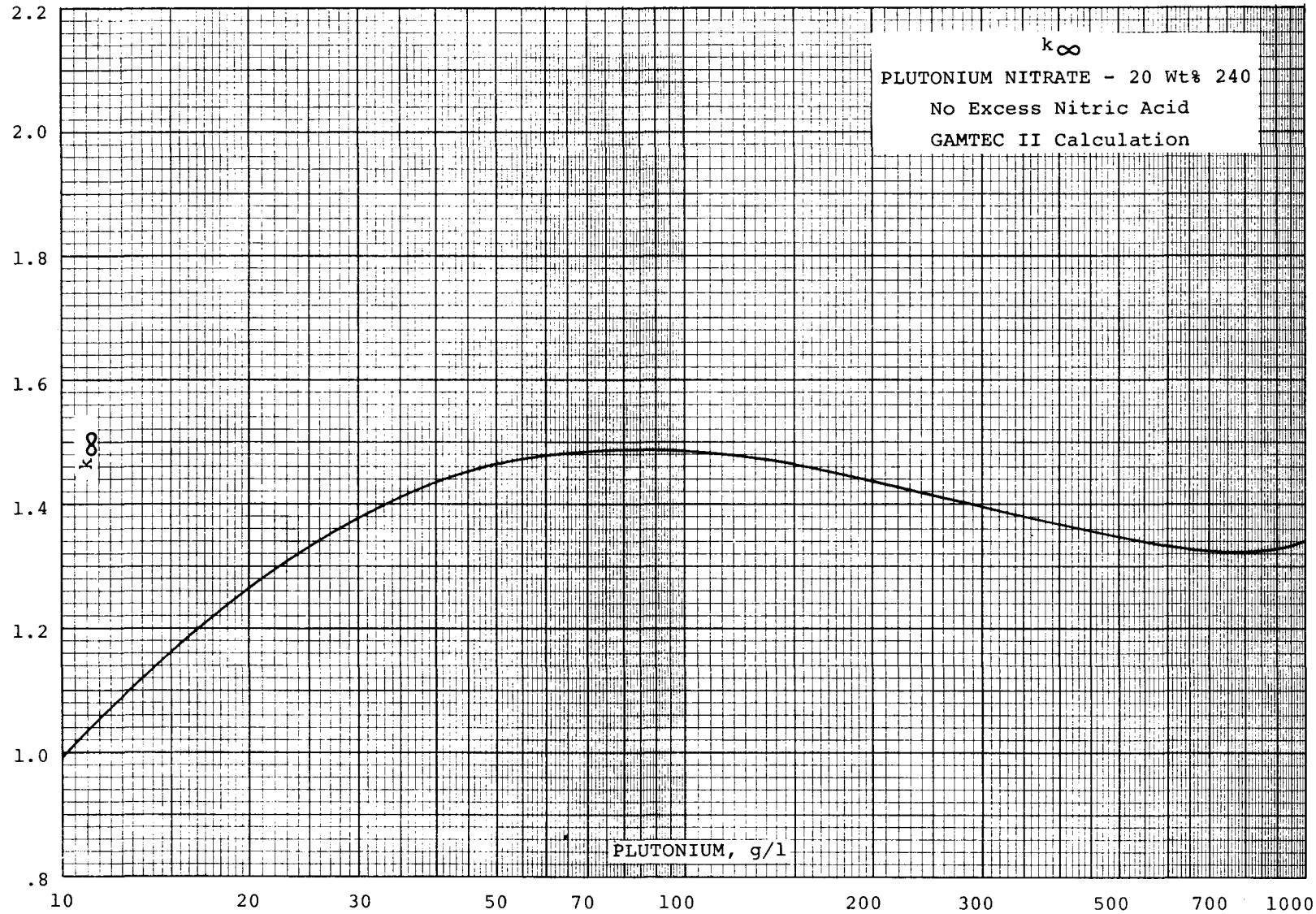

CRITICAL SPHERE VOLUME
vs. CRITICAL SPHERICAL MASS
PLUTONIUM-H2O - 3 Wt% 240
GAMTEC II - HFN - DTF4
Calculation
.01 g/cc
.02
.03
.05
.075
.1
.2
.5
1.0
2.0
3.0
5.0
10.0
19.6
Unreflected
1" H2O Reflection
Full H2O Reflection
CRITICAL SPHERE VOLUME, liter
PLUTONIUM CRITICAL MASS, kg
1000
700
500
300
200
100
70
50
30
20
10
7
5
3
2
1
.7
.5
.3
.2
.1
.1
.2
.3
.5
.7
1
2
3
5
7
10
20
30
50
70
100

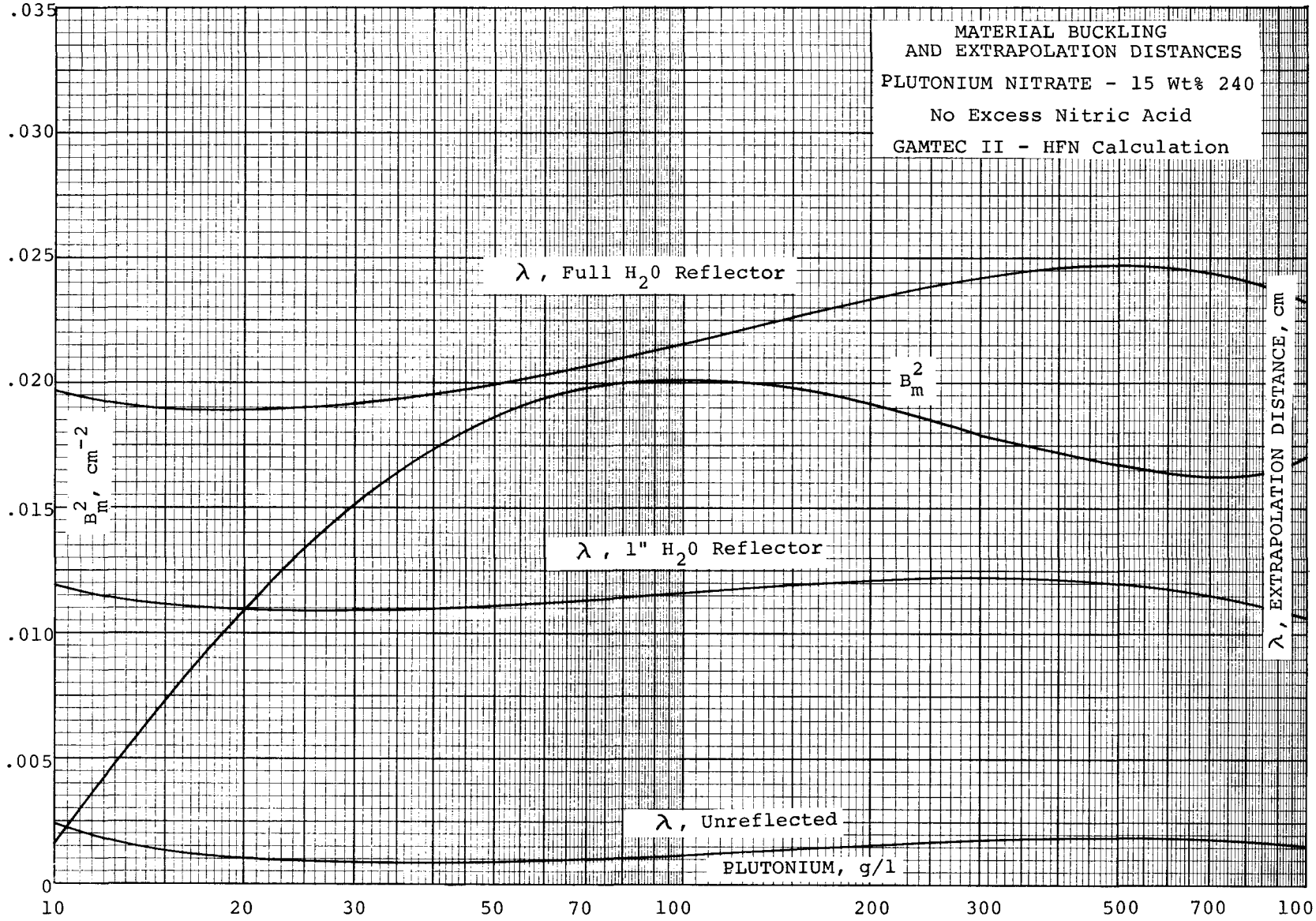

100
70
50
30
20
10
7
5
3
2
1
VOLUME, liters
6M
3M
0M
6M
3M
0M
CRITICAL SPHERE VOLUME
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Calculation
--- Bare System
—— Full Water Reflection
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000

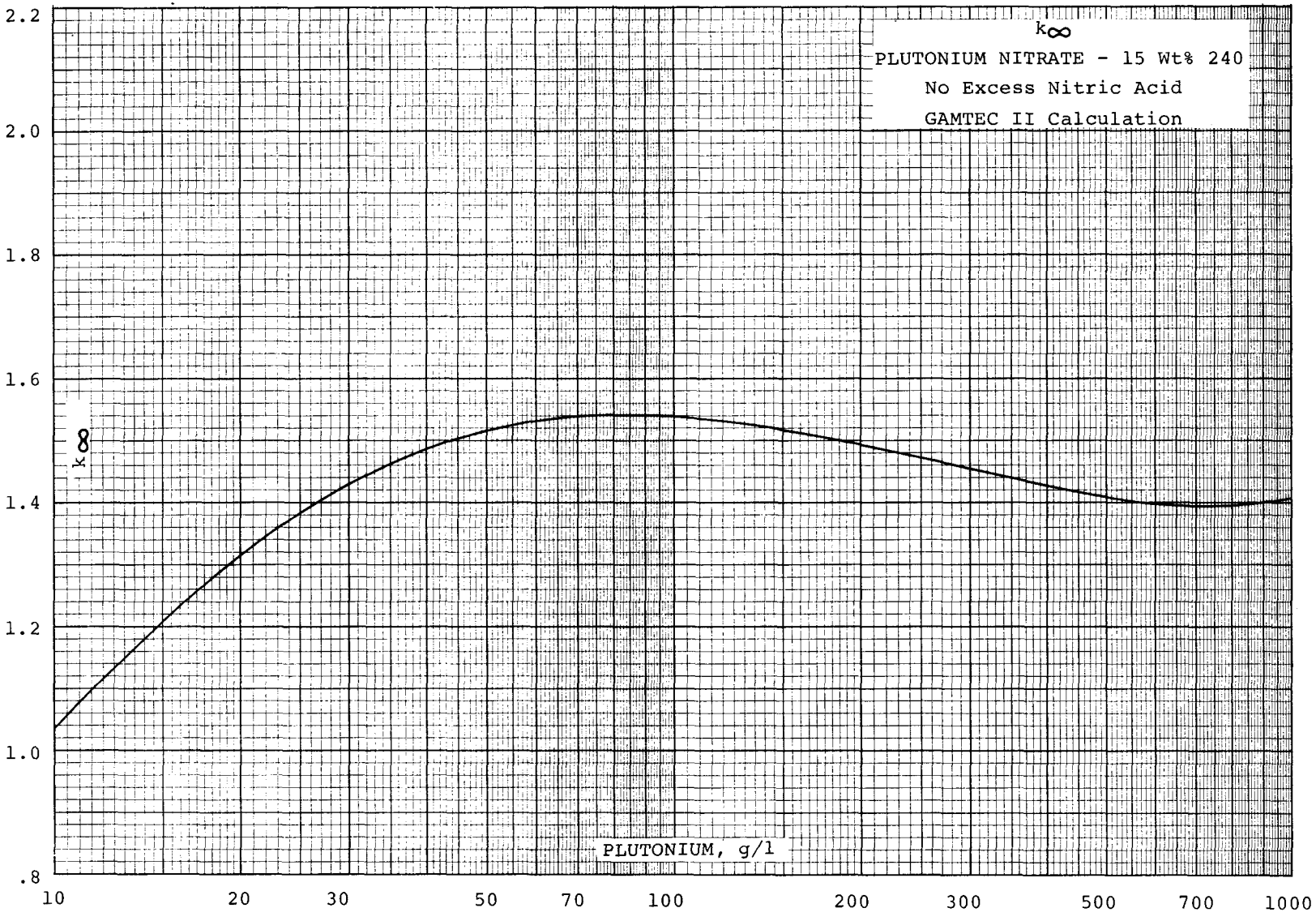

CRITICAL SPHERE VOLUME
NOMINAL (ONE INCH) WATER REFLECTION
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC II - HFN Calculation
VOLUME, liters
PLUTONIUM, g/l
6M
3M
0M
1000
700
500
300
200
100
70
50
30
20
10
10
20
30
50
70
100
200
300
500
700
1000

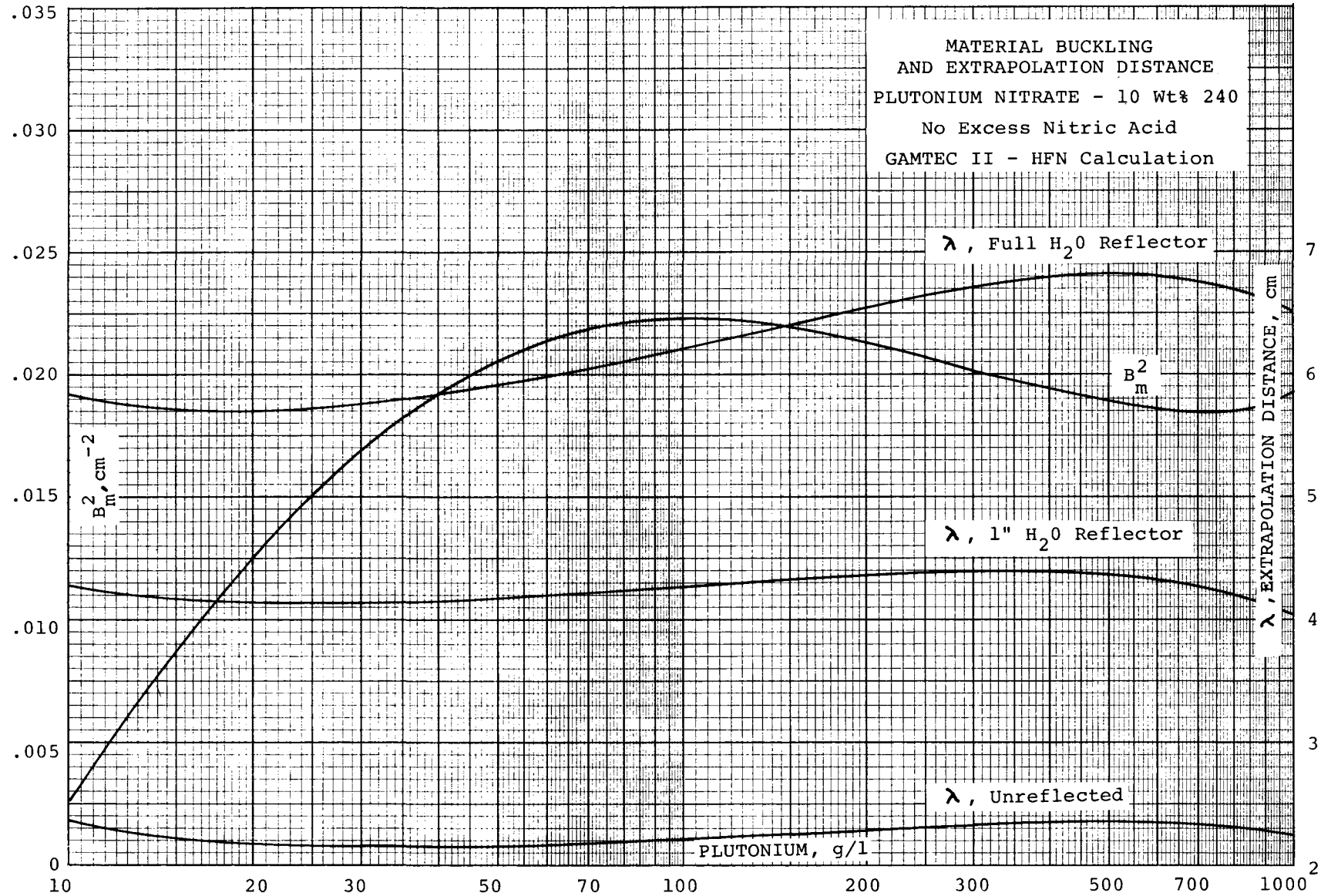

CRITICAL SPHERE VOLUME
PLUTONIUM-H2O - 0 Wt% 240
GAMTEC II - HFN Calculation
Unreflected
1" H2O Reflection
Full H2O Reflection
VOLUME, liters
PLUTONIUM, g/l
100
70
50
30
20
10
7
5
3
2
1
10
20
30
50
70
100
200
300
500
700
1000

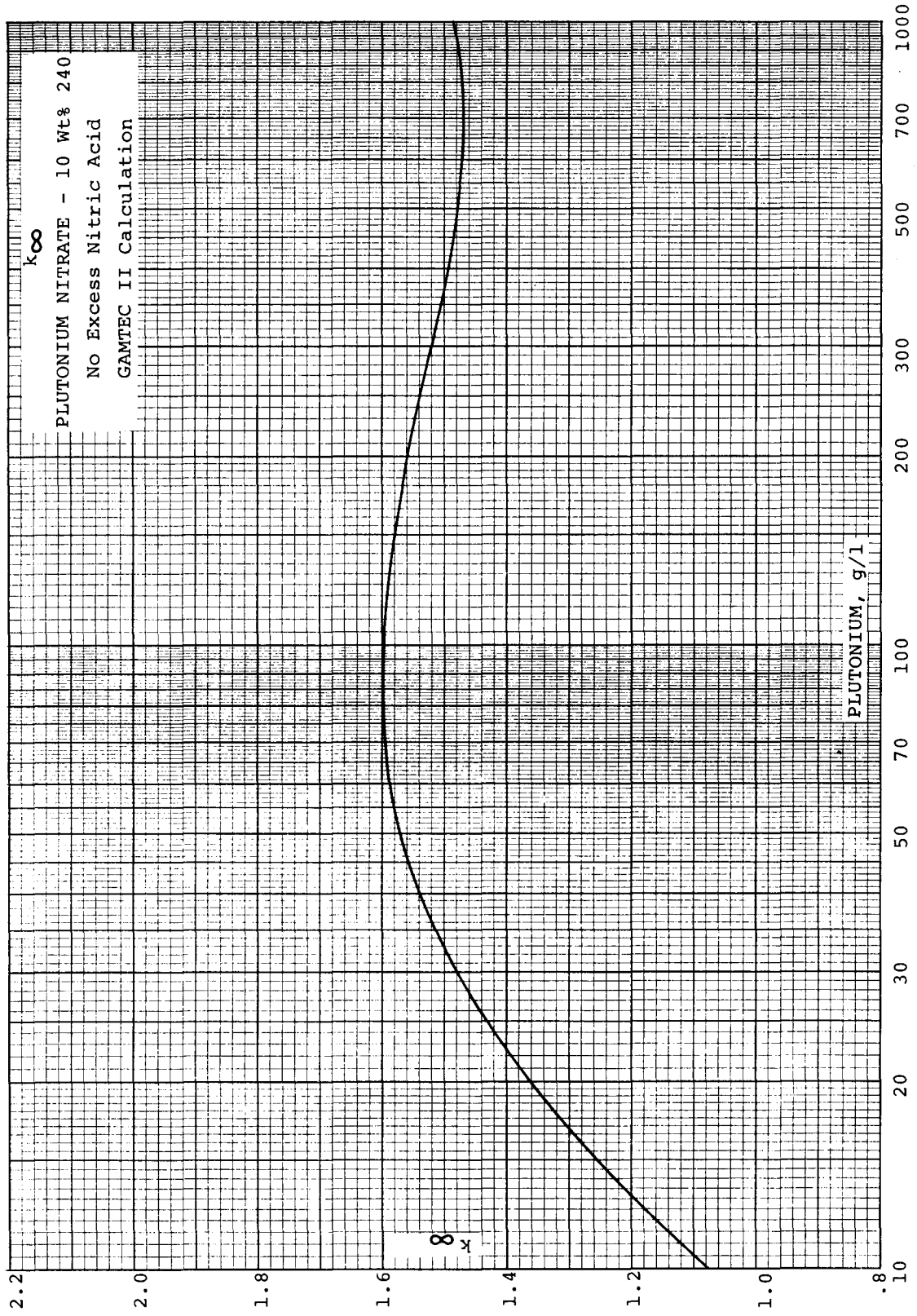

MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCES
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
λ ,Full H2O Reflector
λ ,1" H2O Reflector
λ ,Unreflected
B2m
B2m, cm-2
λ, EXTRAPOLATION DISTANCE, cm
PLUTONIUM, g/l
.030
.025
.020
.015
.010
.005
0
-.005
10
20
30
50
70
100
200
300
500
700
1000
7
6
5
4
3
2


k_∞
PLUTONIUM NITRATE - 20 Wt% 240
No Excess Nitric Acid
GAMTEC II Calculation
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
k_∞
10
20
30
50
70
100
200
300
500
700
1000
PLUTONIUM, g/l

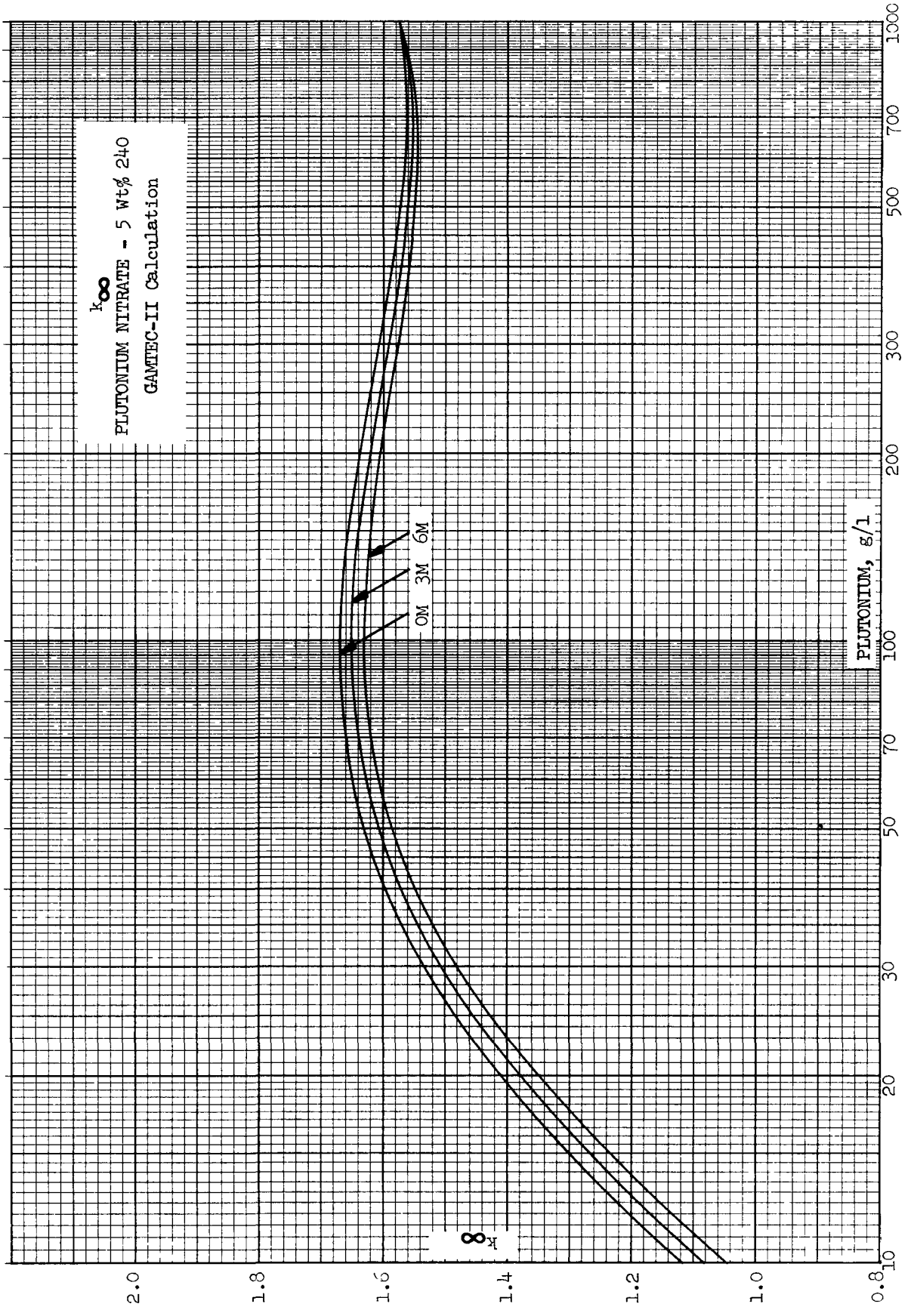

MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCES
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
λ , Full H2O Reflector
λ , 1" H2O Reflector
λ , Unreflected
B2m
B2m, cm-2
λ, EXTRAPOLATION DISTANCE, cm
PLUTONIUM, g/l
.035
.030
.025
.020
.015
.010
.005
0
10
20
30
50
70
100
200
300
500
700
1000
7
6
5
4
3
2


k_∞
PLUTONIUM NITRATE - 15 Wt% 240
No Excess Nitric Acid
GAMTEC II Calculation
k_∞
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
10
20
30
50
70
100
200
300
500
700
1000
PLUTONIUM, g/l

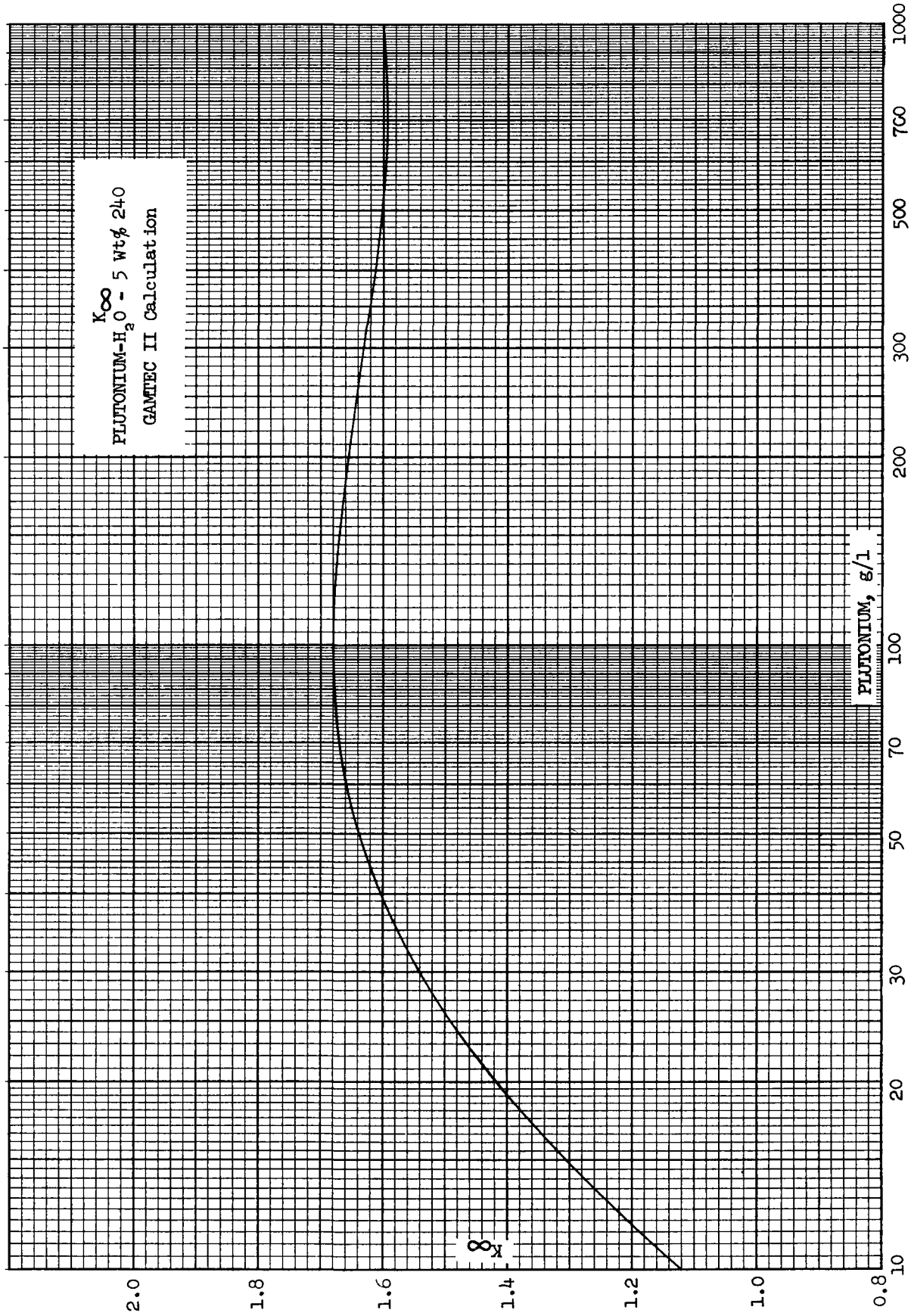

MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCE
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
GAMTEC II - HFN Calculation
λ, Full H20 Reflector
λ, 1" H20 Reflector
λ, Unreflected
B2m
B2m, cm-2
λ, EXTRAPOLATION DISTANCE, cm
PLUTONIUM, g/l
.035
.030
.025
.020
.015
.010
.005
0
10
20
30
50
70
100
200
300
500
700
1000
7
6
5
4
3
2


k_∞
PLUTONIUM NITRATE - 10 Wt% 240
No Excess Nitric Acid
GAMTEC II Calculation
k_∞
PLUTONIUM, g/l
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
10
20
30
50
70
100
200
300
500
700
1000

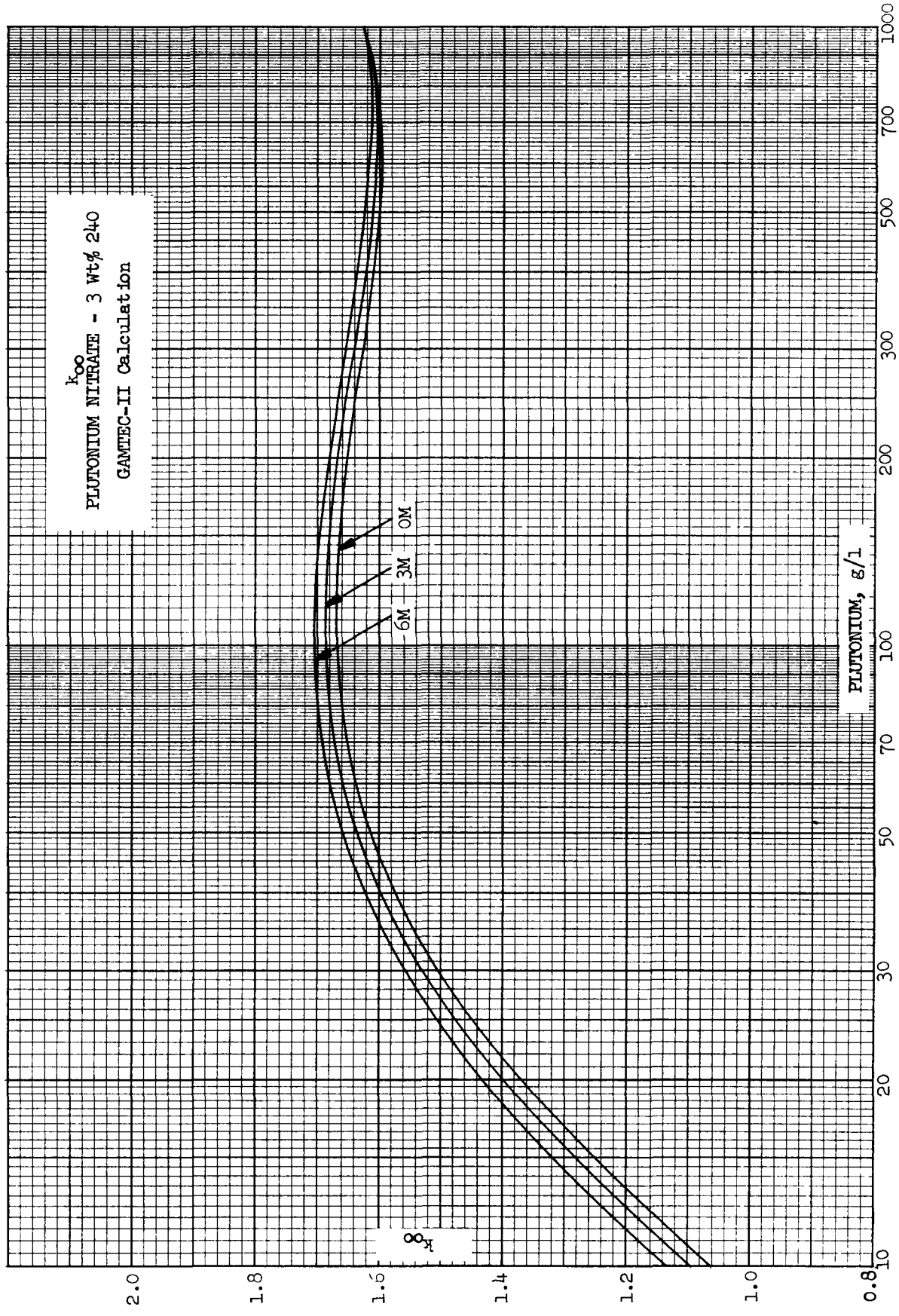
MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCES
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC II - HFN Calculations
0M
3M
6M
B_m^2, cm^{-2}
.025
.020
.015
.010
.005
0
λ, Full Water Reflector
0M 3M 6M
λ, 1" Water Reflector
0M 3M 6M
λ, Unreflected
0M 3M 6M
λ, EXTRAPOLATION DISTANCE, cm
7
6
5
4
3
2
10
20
30
50
70
100
200
300
500
700
1000
PLUTONIUM, g/l

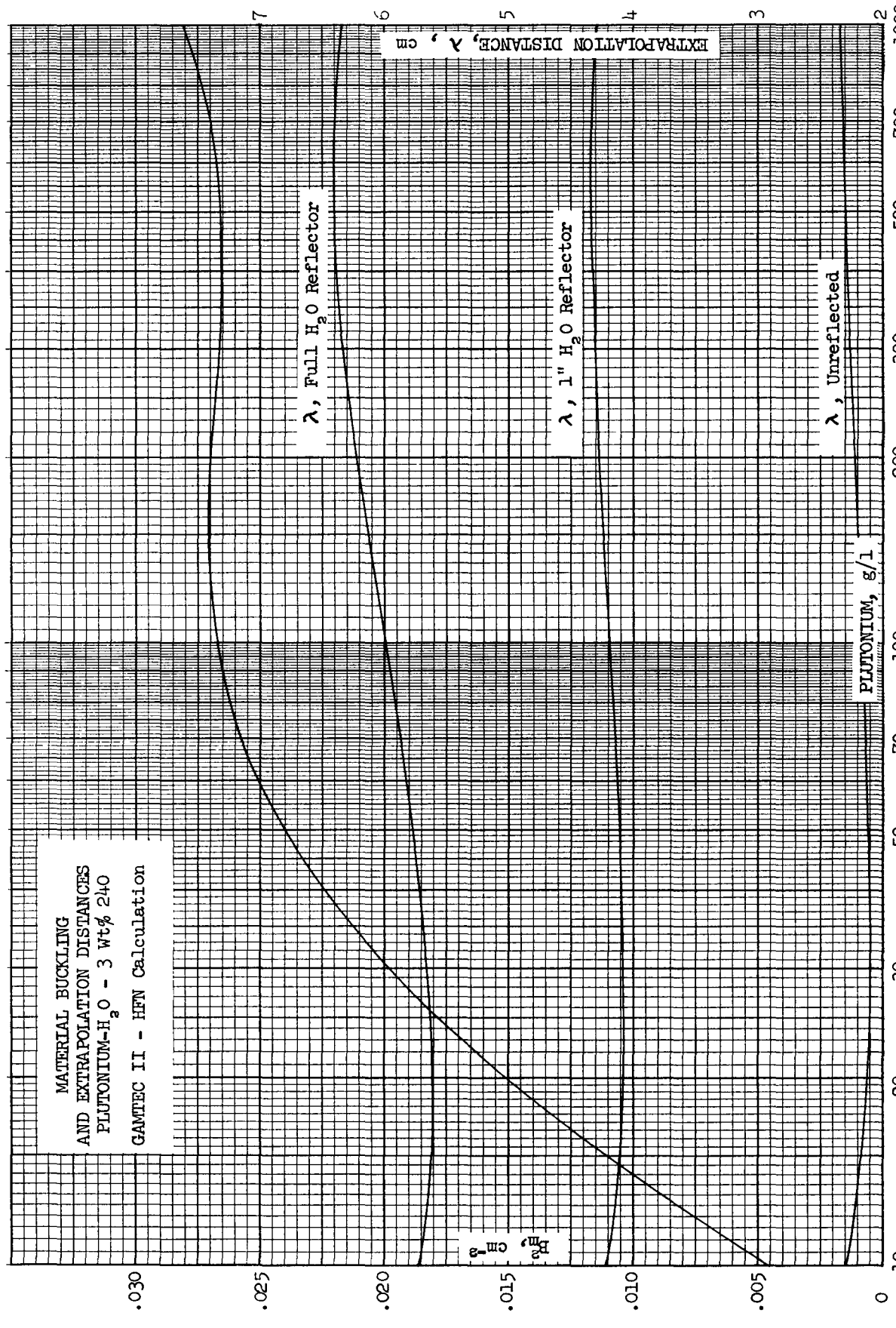

k_∞
PLUTONIUM NITRATE - 5 Wt% 240
GAMTEC-II Calculation
0M
3M
6M
PLUTONIUM, g/l
k_∞
2.0
1.8
1.6
1.4
1.2
1.0
0.8
1000
700
500
300
200
100
70
50
30
20
10

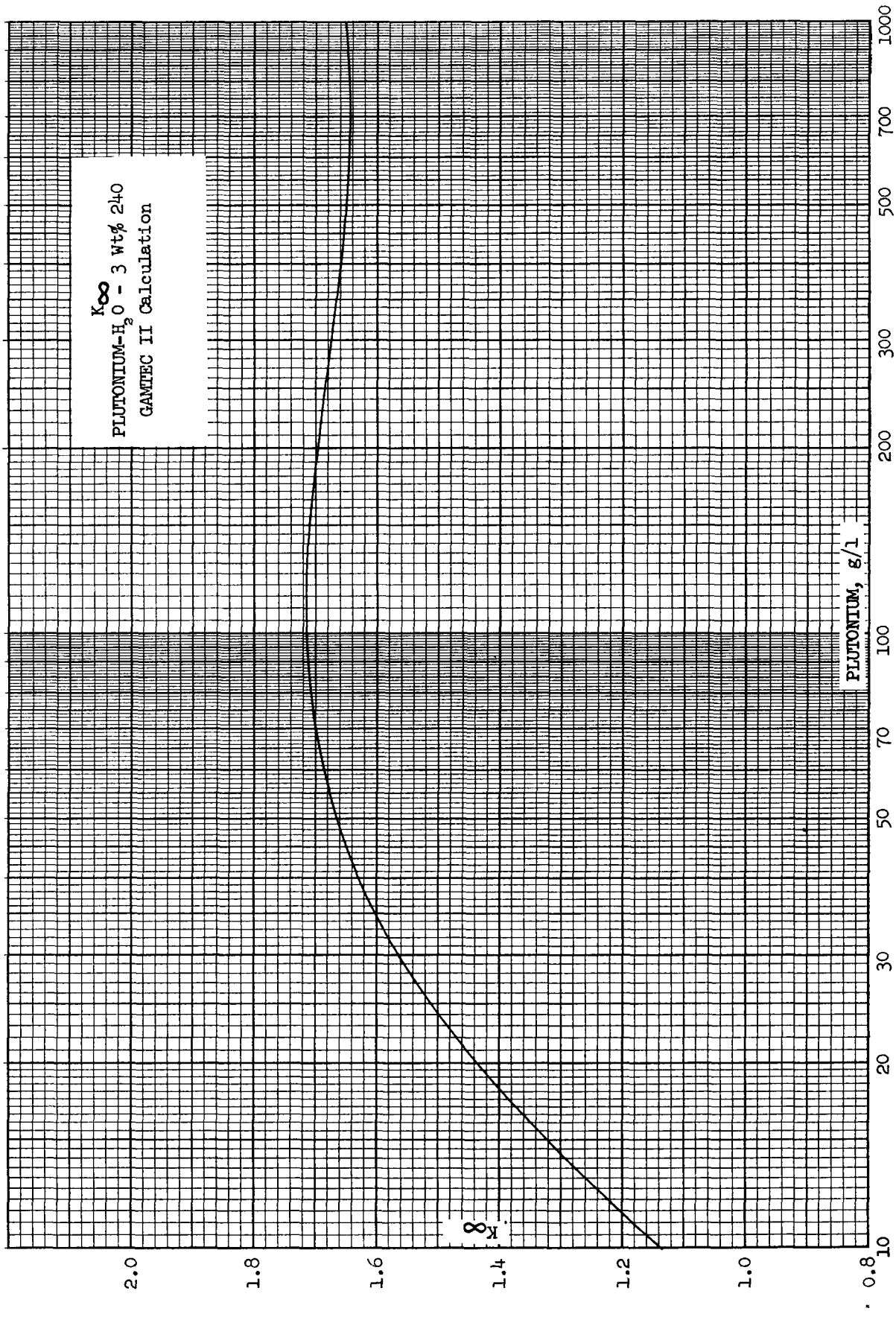
MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCES
PLUTONIUM-H2O - 5 Wt% 240
GAMTEC II - HFN Calculation
λ, Full H2O Reflector
λ, 1" H2O Reflector
λ, Unreflected
B²m, cm⁻²
EXTRAPOLATION DISTANCE, λ, cm
PLUTONIUM, g/l
.035
.030
.025
.020
.015
.010
.005
0
7
6
5
4
3
2
10
20
30
50
70
100
200
300
500
700
1000


K_∞
PLUTONIUM-H_2O - 5 wt% 240
GAMTEC II Calculation
PLUTONIUM, g/l
K_∞
2.0
1.8
1.6
1.4
1.2
1.0
0.8
10
20
30
50
70
100
200
300
500
700
1000

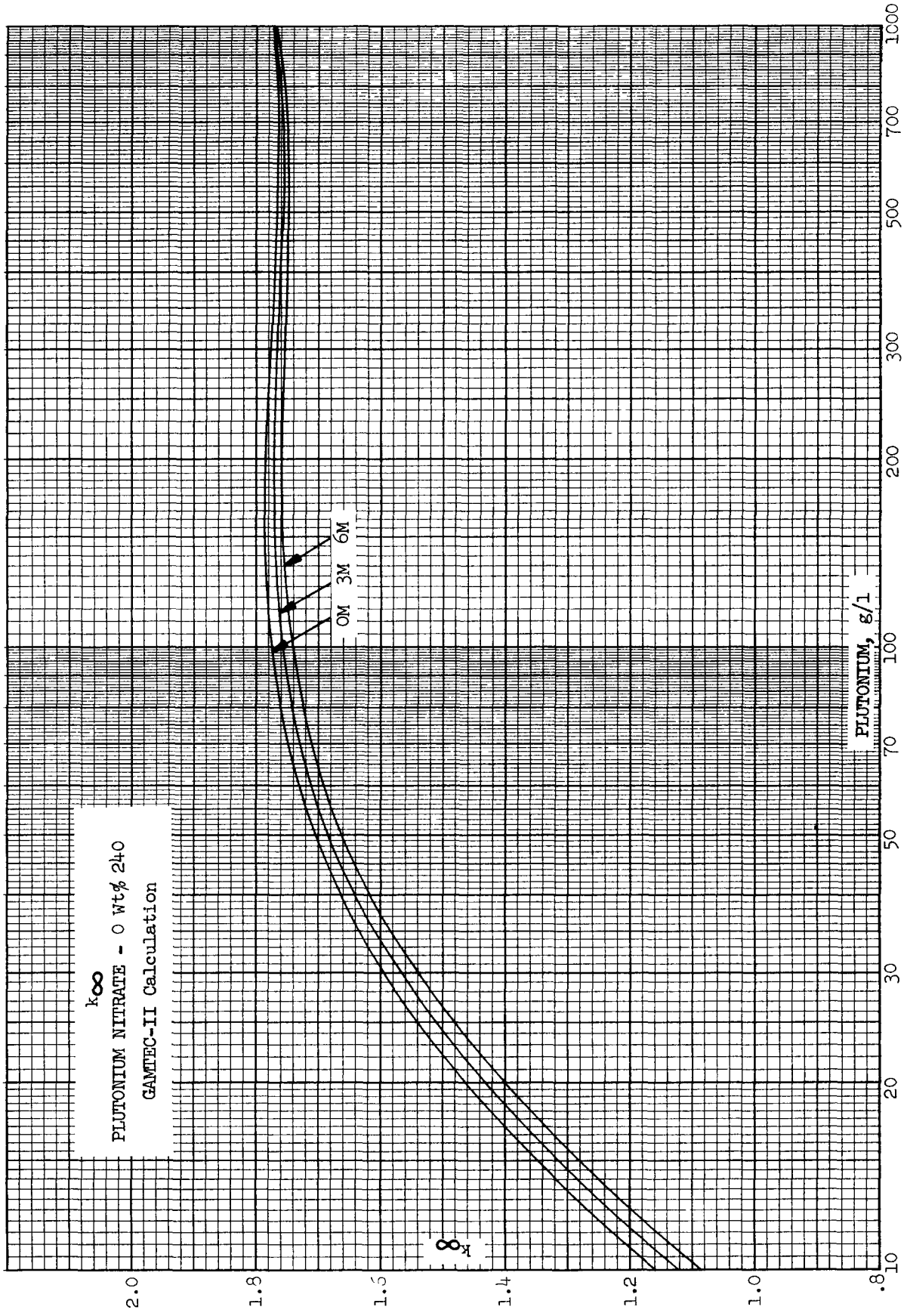
MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCES
PLUTONIUM NITRATE - 3 Wt% 240
GAMTEC-HFN Calculations
B_m^2, cm^{-2}
.030
.025
.020
.015
.010
.005
0
0M
3M
6M
λ , Full Water Reflector
λ , 1" Water Reflector
λ , Unreflected
λ , EXTRAPOLATION DISTANCE, cm
7
6
5
4
3
2
10
20
30
50
70
100
200
300
500
700
1000
PLUTONIUM, g/l

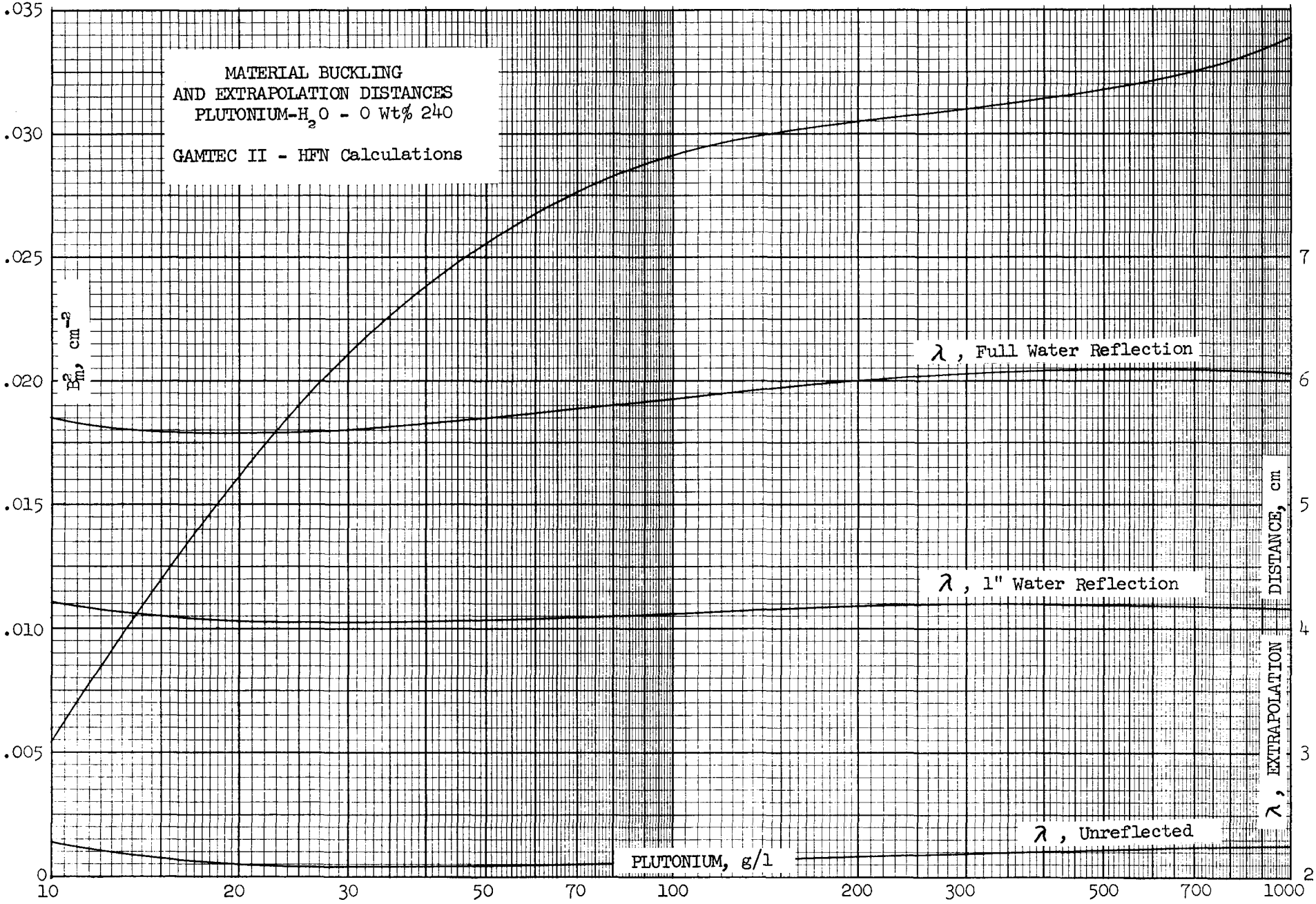

k_∞
PLUTONIUM NITRATE - 3 wt% 240
GAMTEC-II Calculation
0M
3M
6M
PLUTONIUM, g/l
k_∞
2.0
1.8
1.6
1.4
1.2
1.0
0.8
1000
700
500
300
200
100
70
50
30
20
10

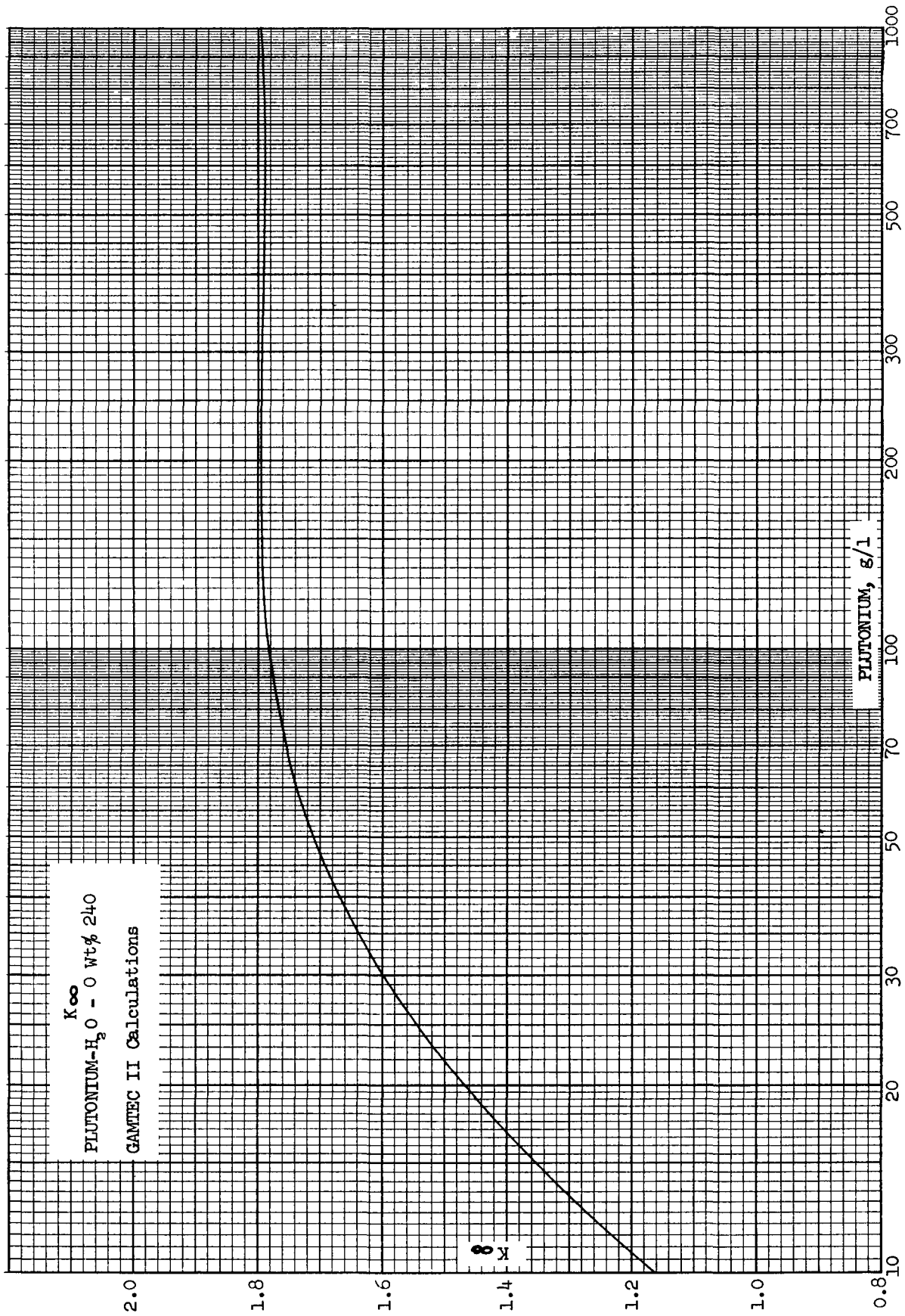

MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCES
PLUTONIUM-H_2O - 3 Wt% 240
GAMTEC II - HFN Calculation
B_m^2, cm^{-2}
EXTRAPOLATION DISTANCE, λ, cm
PLUTONIUM, g/l
λ, Full H_2O Reflector
λ, 1" H_2O Reflector
λ, Unreflected
.030
.025
.020
.015
.010
.005
0
10
20
30
50
70
100
200
300
500
700
1000
7
6
5
4
3
2


K_∞ PLUTONIUM-H_2O - 3 wt% 240
GAMTEC II Calculation
PLUTONIUM, g/l
K_∞
2.0
1.8
1.6
1.4
1.2
1.0
0.8
1000
700
500
300
200
100
70
50
30
20
10

MATERIAL BUCKLING
AND EXTRAPOTION DISTANCES
PLUTONIUM NITRATE - 0 Wt% 240
GAMTEC-II - HFN Calculations
B_m^2, cm^{-2}
EXTRAPOLATION DISTANCE, cm
PLUTONIUM, g/l
λ, Full Water Reflector
λ, 1" Water Reflector
λ, Unreflected
0M
3M
6M
.035
.030
.025
.020
.015
.010
.005
0
10
20
30
50
70
100
200
300
500
700
1000
7.0
6.0
5.0
4.0
3.0
2.0


k_∞
PLUTONIUM NITRATE - 0 wt% 240
GAMTEC-II Calculation
0M
3M
6M
PLUTONIUM, g/l
k_∞
2.0
1.8
1.6
1.4
1.2
1.0
.8
10
20
30
50
70
100
200
300
500
700
1000


MATERIAL BUCKLING
AND EXTRAPOLATION DISTANCES
PLUTONIUM-H_2O - 0 Wt% 240
GAMTEC II - HFN Calculations
B_m^2, cm^{-2}
.035
.030
.025
.020
.015
.010
.005
0
λ , Full Water Reflection
λ , 1" Water Reflection
λ , Unreflected
PLUTONIUM, g/l
10
20
30
50
70
100
200
300
500
700
1000
λ , EXTRAPOLATION DISTANCE, cm
7
6
5
4
3
2


K_∞
PLUTONIUM-H_2O - 0 wt% 240
GAMTEC II Calculations
K_∞
PLUTONIUM, g/l
2.0
1.8
1.6
1.4
1.2
1.0
0.8
10
20
30
50
70
100
200
300
500
700
1000

III. HOMOGENEOUS DATA

B. URANIUM-235 SYSTEMS

1. Correlation Between Calculation and Experiment
2. H/U versus Uranium g/l Relationship
3. Critical Sphere Dimensions

   Earlier graphs within these divisions have the percentage by weight of the major fissile isotope (U-235) as the fourth identification number (e.g., III.B.3.97-2 would signify the second graph showing data for uranium containing 97 weight percent U-235). Because the use of fractional percentages made the page number difficult to read, later graph identification has been changed to set off the weight percent by parentheses, III.B.3(97)-2, in the interest of clarity.

4. Critical Cylinder Dimensions
5. Critical Slab Dimensions
6. Critical Mass - Sphere
7. Critical Mass per Unit Height - Cylinder
8. Critical Mass per Unit Area - Slab
9. Critical Volume
10. Material Bucklings
11. Infinite Multiplication Factor

BASIC URANIUM-235 CRITICAL PARAMETERS

These basic values are taken from references which would normally be used as bases for standards. ARH-600 values compare favorably.

METAL	Full Reflection*	Bare**[3]
Minimum critical spherical mass, Kg ^{235}U 18.82 g/cm^3	21.85[1]	
Minimum critical spherical mass, Kg ^{235}U(93.5) 18.8 g/cm^3	22.8[2]	47.
Infinite cylinder diameter, inches, ^{235}U 18.82 g/cm^3	3.0[1]	4.5
Infinite slab thickness, inches, ^{235}U 18.82 g/cm^3	0.586[1]	2.2
Minimum spherical volume, liters, ^{235}U 18.82 g/cm^3	1.16[1]	2.7
HOMOGENEOUS SOLUTIONS[4]		
Minimum critical mass, g ^{235}U	820	1400
Infinite cylinder diameter, inches	5.63	8.5
Infinite slab thickness, inches	1.93	4.5
Minimum spherical volume, liters	6.1	14.0
Minimum areal concentration g/ft^2	390	~520
Minimum critical aqueous concentration, g/l ^{235}U	12.1	
Minimum enrichment for criticality, Wt% ^{235}U[5]	1.034 ± 0.010	
Minimum enrichment for criticality for UNH solutions, Wt% ^{235}U[6]	2.104 ± 0.010	

* Reflector is water unless otherwise specified.

** "Bare" solutions have 1/16-inch stainless steel reflector.

(1) W. H. Roach and D. R. Smith. "Estimates of Maximum Subcritical Dimensions of Single Fissile Metal Units", ORNL-CDC-3, October, 1967, (reflected metal systems).

(2) G. A. Graves and H. C. Paxton. "Critical Masses of Oralloy Assemblies", Nucleonics 15, No. 6, 90, June, 1957, (bare metal systems).

(3) H. C. Paxton, et al. "Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu and ^{233}U", TID-7028, June, 1964, (for all "bare" systems unless otherwise noted; solutions are U(93.2)-H_2O with correction for H/U relationships of actual solutions).

(4) J. W. Webster. "Calculated Neutron Multiplication Factors of Uniform Aqueous Solutions of ^{233}U and ^{235}U", ORNL-CDC-2, October, 1967, (for reflected U(100)O_2F_2 systems unless noted otherwise).

(5) H. E. Handler. "Measurement of Multiplication Constant of Slightly Enriched Homogeneous UO_3-H_2O Mixture and Minimum Enrichment for Criticality", USAEC Report, HW-70310, August, 1961.

(6) S. R. Bierman and G. M. Hess. "Minimum Critical ^{235}U Enrichment of Homogeneous Hydrogeneous Uranyl Nitrate", ORNL-CDC-5, June, 1968.

III.B.1 Correlations Between Calculations and Experiment

The data for 3 weight percent uranium trioxide and 93.2 weight percent uranyl nitrate in this section was obtained by the GAMTEC II (reference 1) and HFN (reference 2) codes. The GAMTEC II code was used to produce 18 neutron energy group cross-section sets that, in turn, were used in the HFN one-dimensional diffusion theory code to produce critical sizes, extrapolation distances and material bucklings. Unless otherwise indicated, the material bucklings for the other enrichments and the k_∞ and migration areas were obtained from the GAMTEC II code alone. GAMTEC II utilizes a special averaging technique to calculate two-group constants, one broad fast group and one thermal group. From these two group constants the code calculates the material buckling and k_∞.

These parameters for low enriched uranium and the correlation of the GAMTEC II code to experimental data have been reported previously (reference 3).

The migration areas provided by the GAMTEC II code are high compared with those calculated using HFN material bucklings and GAMTEC k_∞. When using the GAMTEC migration areas and material buckling, a k_{eff} within one percent of that calculated using HFN migration areas and material bucklings will result. Therefore, these GAMTEC 2-group parameters are included until the more accurate GAMTEC-HFN calculations for desired enrichments are justified.

The calculated effective multiplication constant of critical experiments obtained from GAMTEC II - DTF IV (reference 4) (18 groups) are also shown in this section. These results are included to show the calculational accuracy of the DTF IV code using multigroup constants of uranium provided by GAMTEC II.

In some cases, comparison is made with data from the criticality handbook issued by the United Kingdom Atomic Energy Authority(5) and is referenced as AHSB(U.K.) or U.K.

- -

(1) L. L. Carter, C. R. Richey, C. E. Hughey, "GAMTEC II," BNWL-52, 1965.

(2) J. R. Lillie, "Computer Code HFN," HW-71545, 1961.

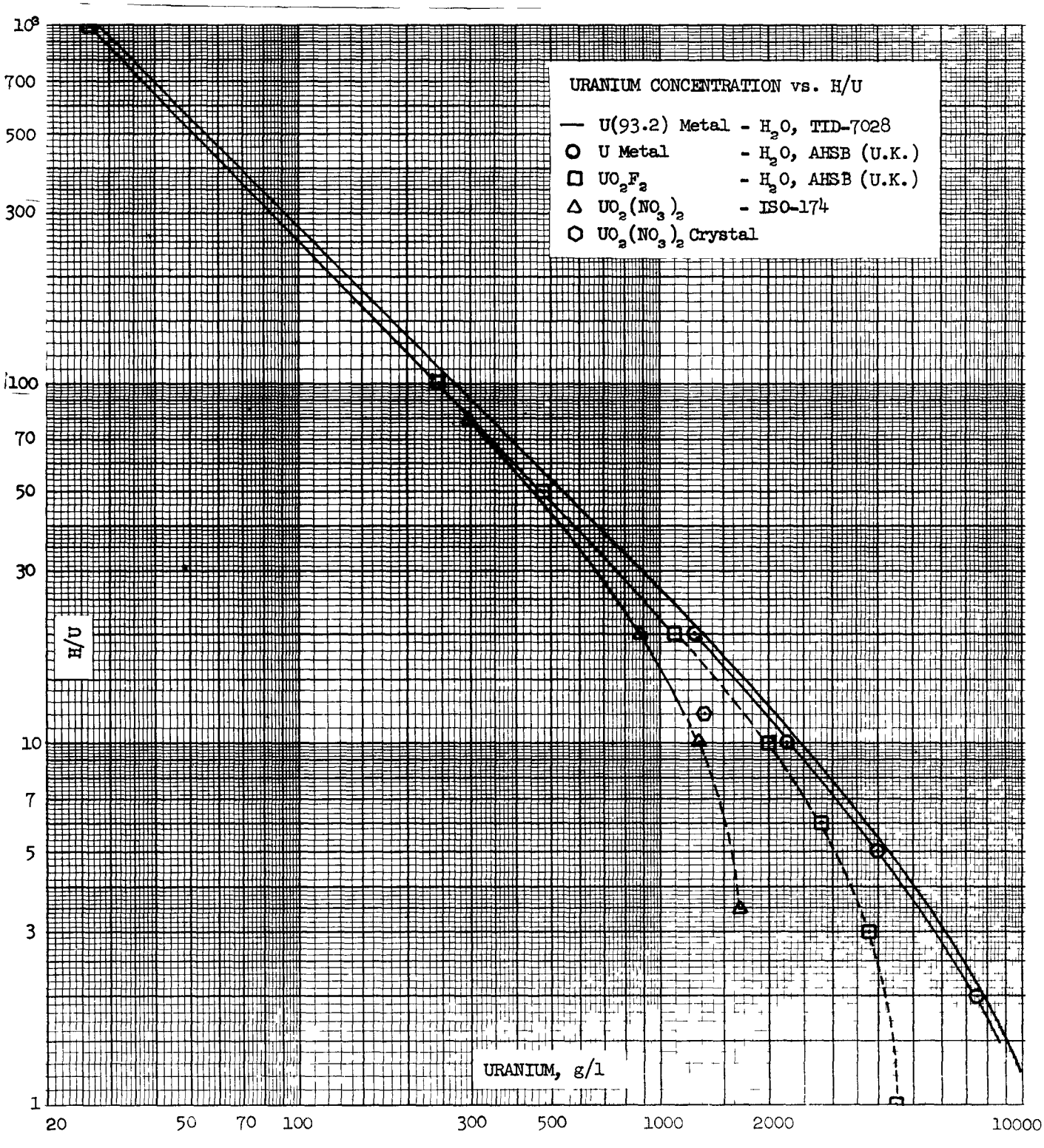
(3) K. R. Ridgway, "Calculated Critical Parameters of Low Enriched Uranium," ISO-174 and ISO-SA-4, 1966.

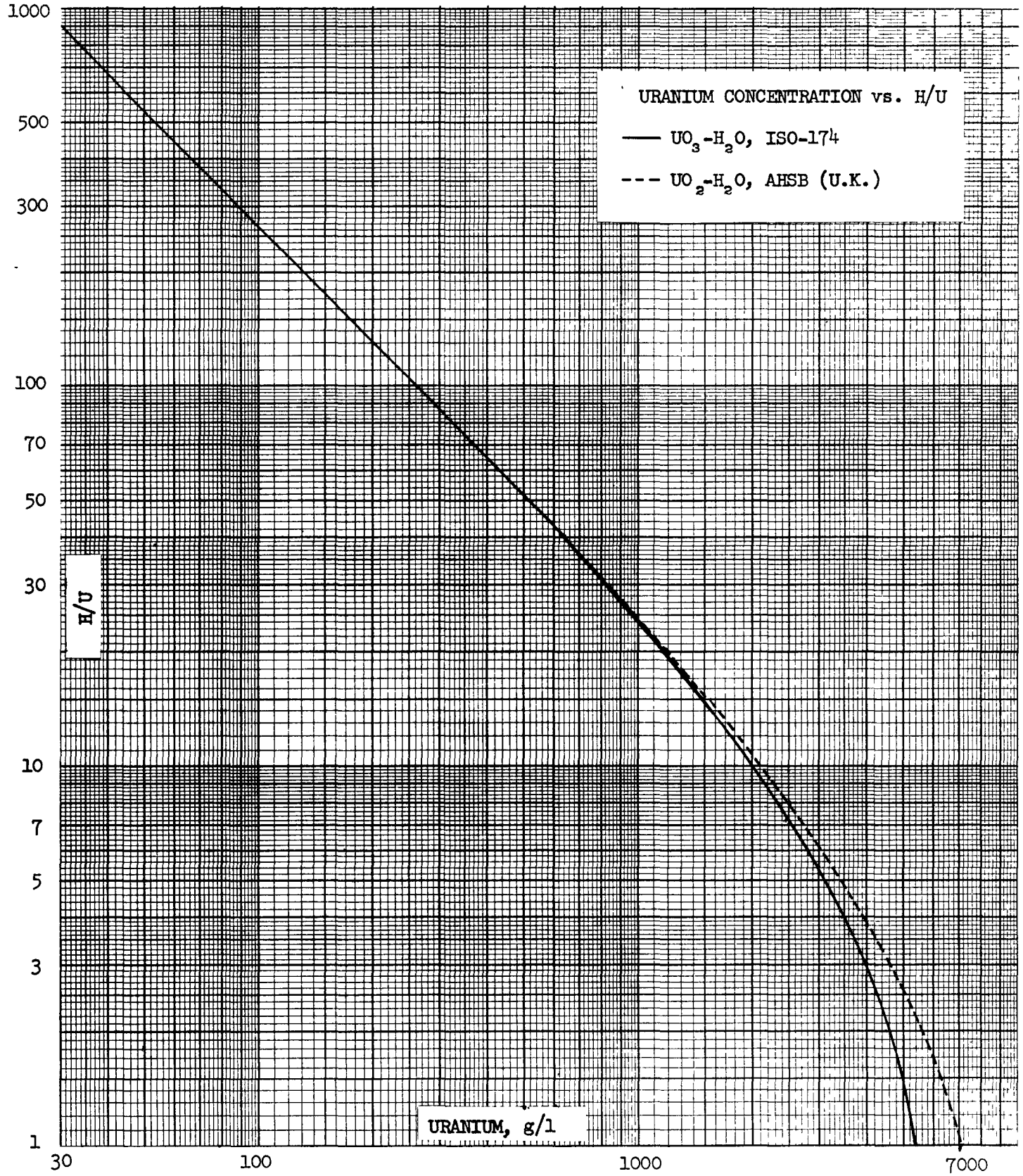
(4) K. D. Lathrop, "A Fortran IV Program for Solving the Multigroup Transport Equation with Anaisotropic Scattering," LA-3376, 1965.

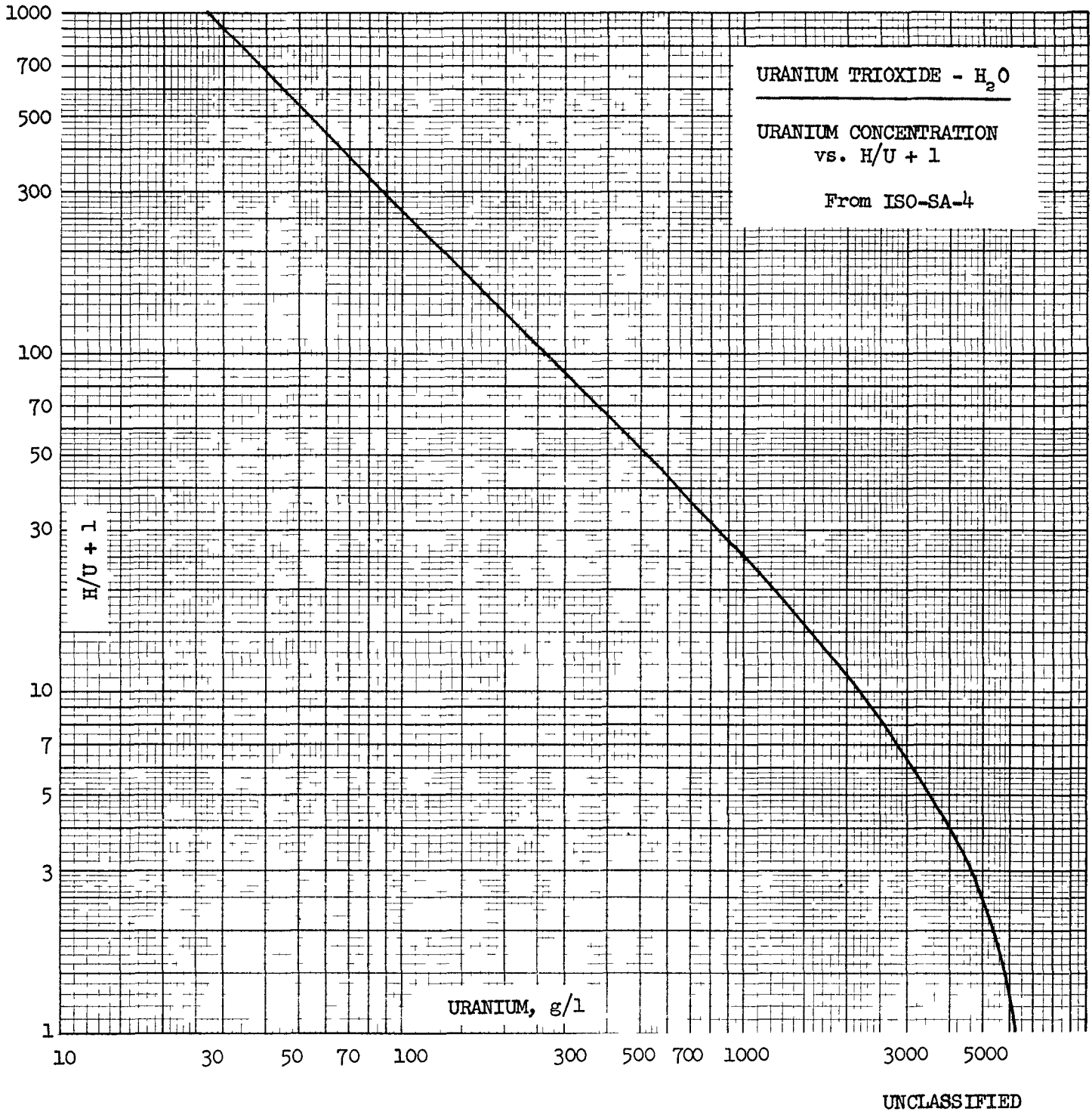
(5) J. H. Chalmers, et al, "Handbook of Criticality Data, Vol. 1," AHSB(S) Handbook 1, (1st Revision), 1967.

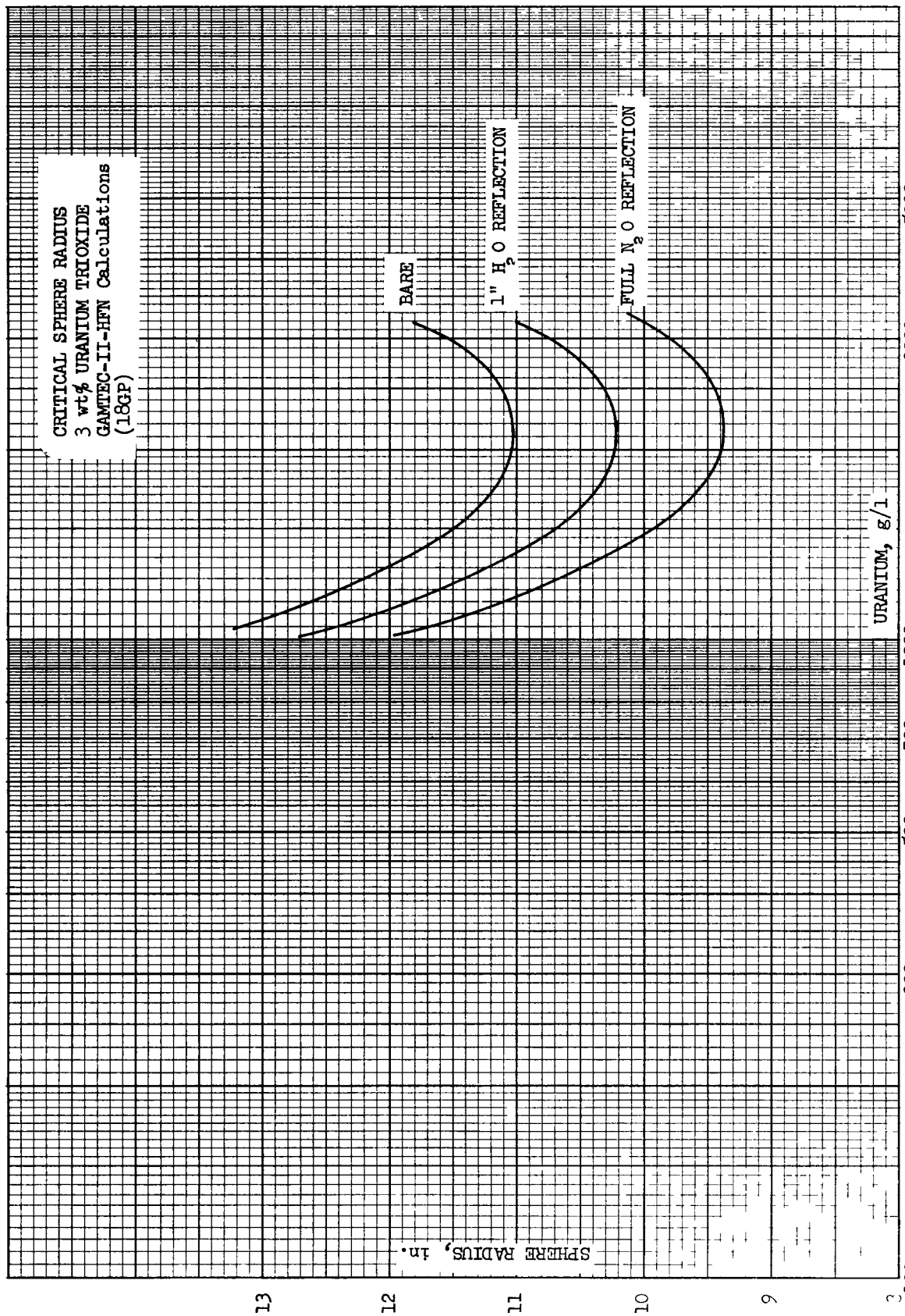
GAMTEC II - HFN and DTF IV calculations of critical experiments are listed below:

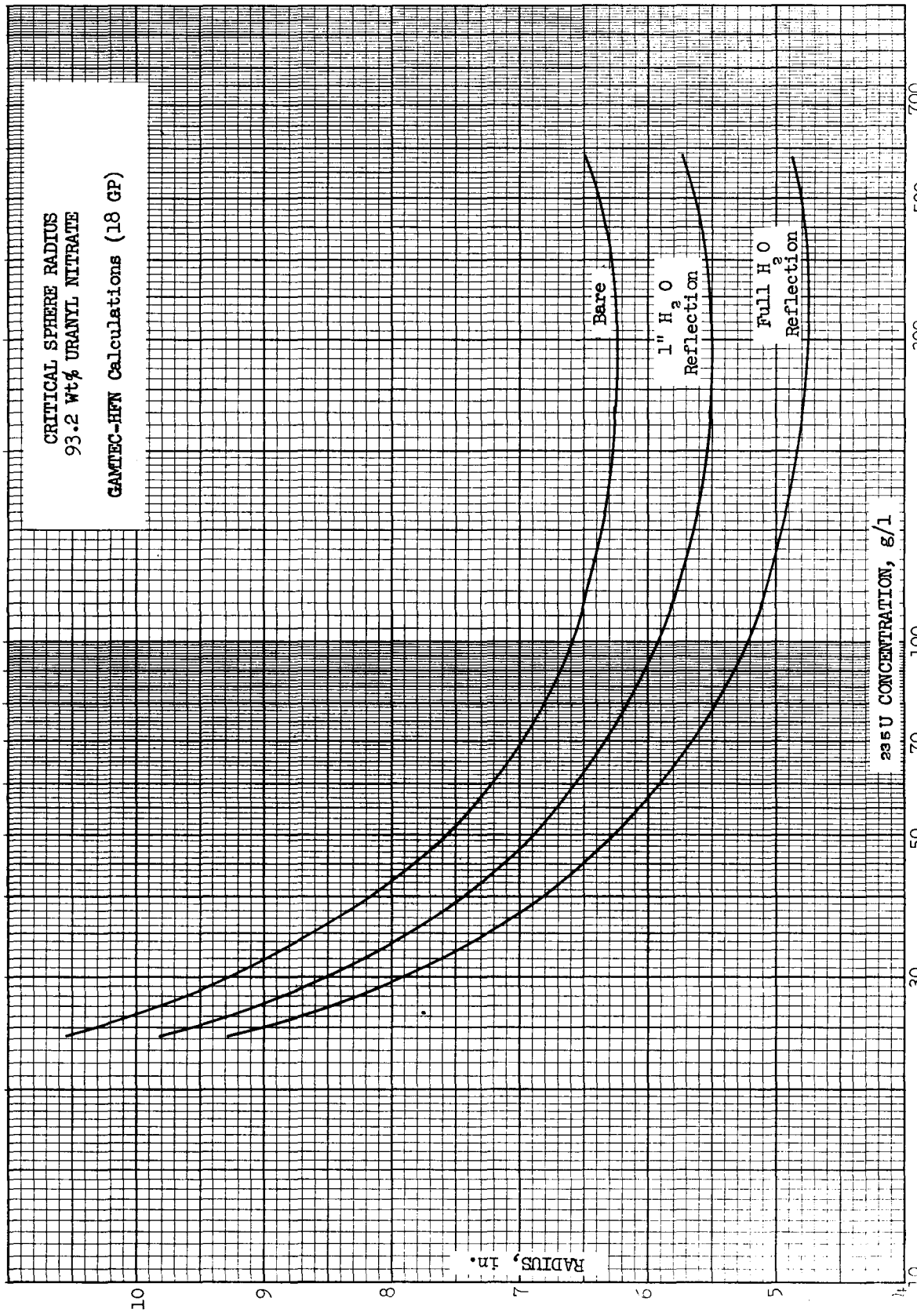
	K-Effective	
	GAMTEC-HFN	GAMTEC-DTF
ORNL-TM-1195 $U(4.98)O_2F_2$ 901 g U/l		
15.39" I.D. Cylinder 40.04" high	0.989	0.996
ORNL-2968 $U(4.89)_3O_8$ In Sterotex 47.9 g U-235/l		
Bare 24" x 24" x 18.8"	0.995	0.993
Full H_2O Reflection 20" x 20" x 13.1"	0.988	0.987
ORNL-1926 $U(93.2)O_2F_2$		
20" x 20" x 2.75" Full Reflection, 347.7 g U-235/l	0.9951	
6" I.D. Aluminum Cylinder 35.43" high, Full Reflection, 830.9 g U-235/l		1.0080
10" I.D. Aluminum Cylinder 5.17" high, Full Reflection, 830.9 g U-235/l		0.9773
10" I.D. Aluminum Cylinder 15.17" high, Bare, 830.9 g U-235/l		1.0028
ORNL-3973 $U(4.98)O_2F_2$ 910.18 g U/l, Bare		
19.99 I.D. stainless steel (.020") sphere		1.0041
15.5" I.D. stainless steel (.031") bare		1.0042
ORNL-2367 $U(93.2)O_2F_2$ 331.4 g U-235/l, 10" O.D. Aluminum (4/16") Annular Tank, Full Reflection on Outside Except Top		
4" I.D. filled with H_2O 9.37" high		0.9973
4" I.D. with air 10.87" high		1.0491
4" I.D. 20 mil Cd sheet & air 12.56" high		1.0300
4" I.D. 20 mil Cd sheet & H_2O 17.87" high		0.9754

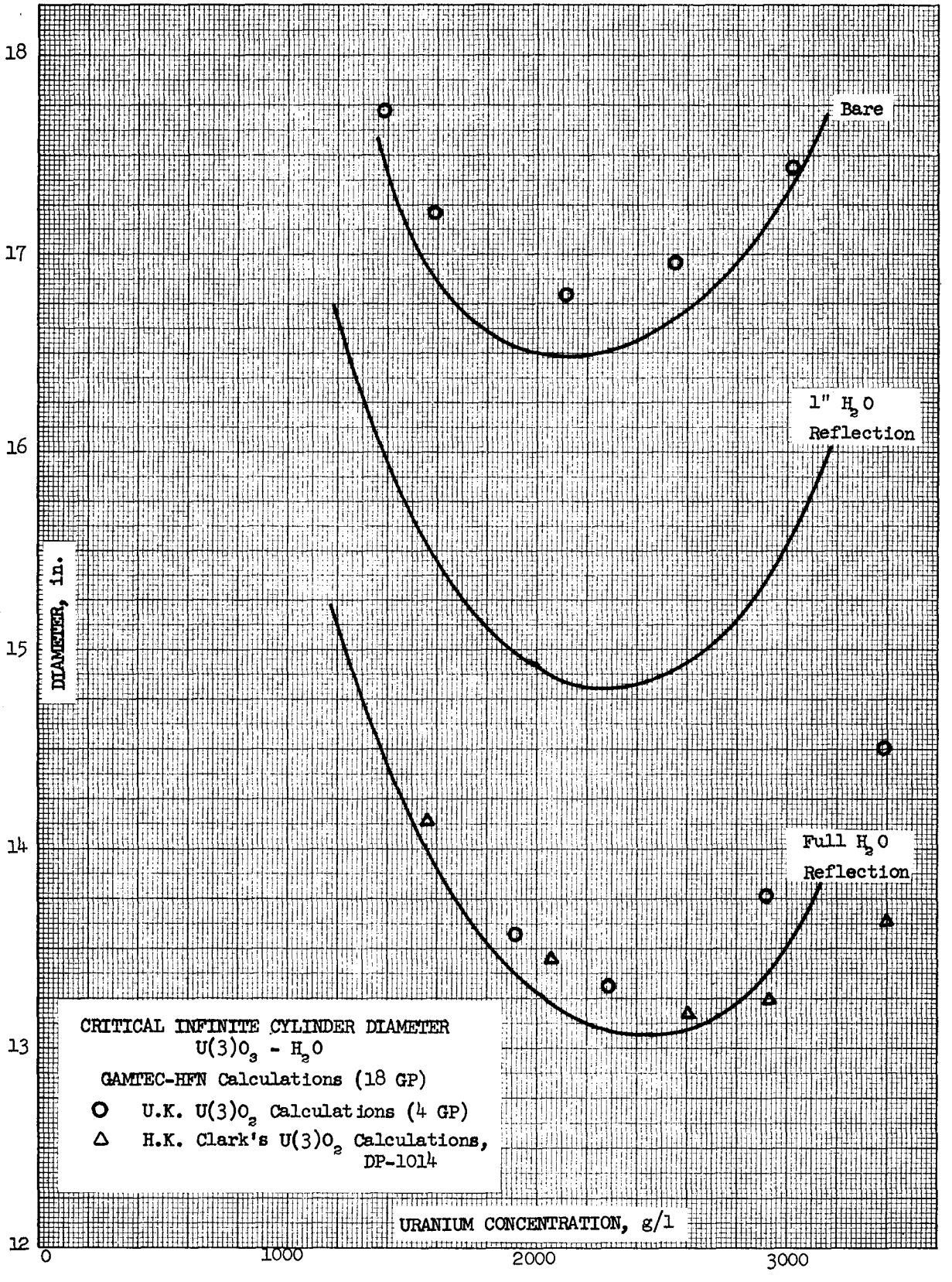

URANIUM CONCENTRATION vs. H/U
U(93.2) Metal - H_2O, TID-7028
U Metal - H_2O, AHSB (U.K.)
UO_2F_2 - H_2O, AHSB (U.K.)
$UO_2(NO_3)_2$ - ISO-174
$UO_2(NO_3)_2$ Crystal
H/U
10^3
700
500
300
100
70
50
30
10
7
5
3
1
URANIUM, g/l
20
50
70
100
300
500
1000
2000
10000

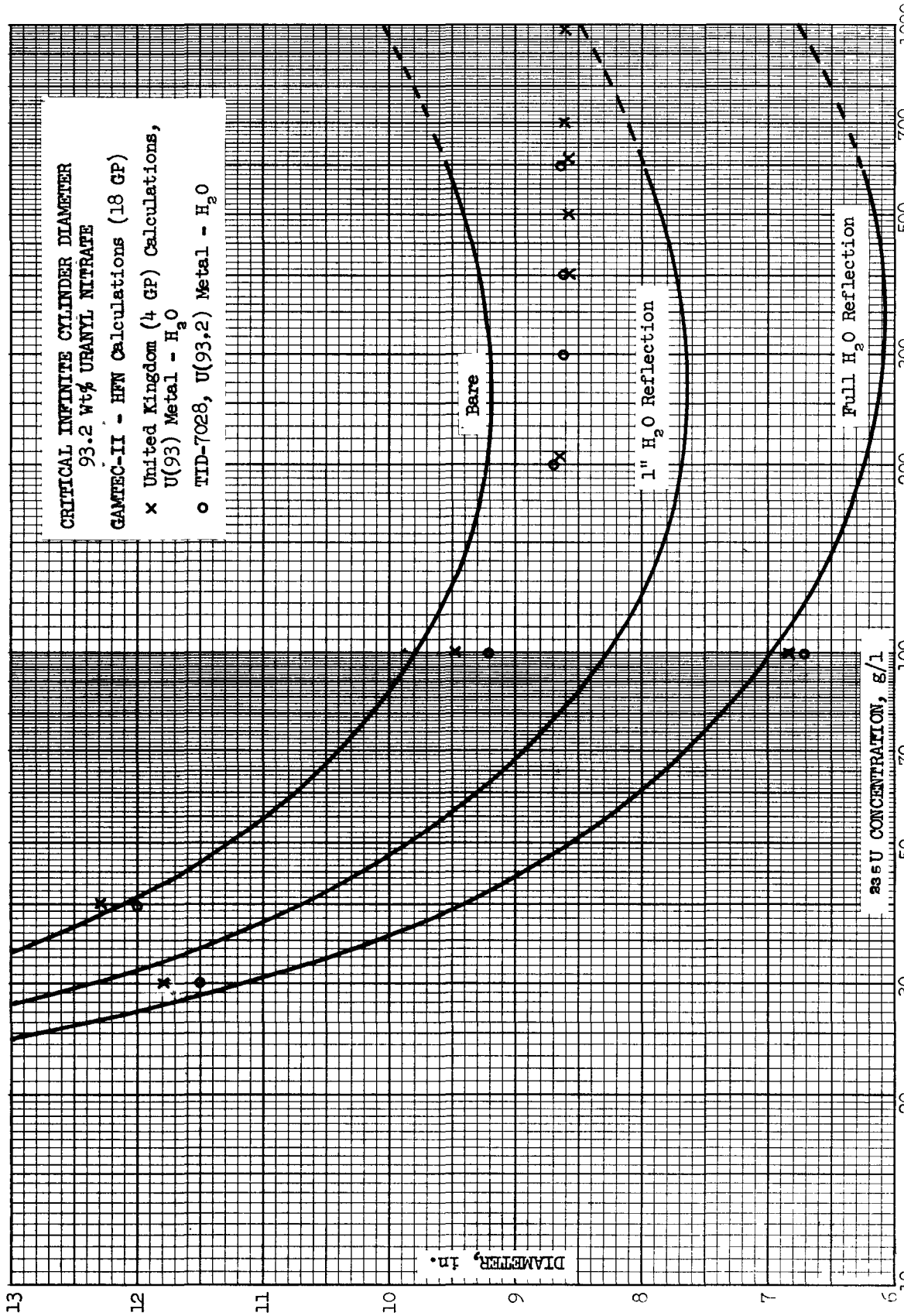

URANIUM CONCENTRATION vs. H/U
—— UO_3-H_2O, ISO-174
--- UO_2-H_2O, AHSB (U.K.)
H/U
1000
500
300
100
70
50
30
10
7
5
3
1
30
100
1000
7000
URANIUM, g/l

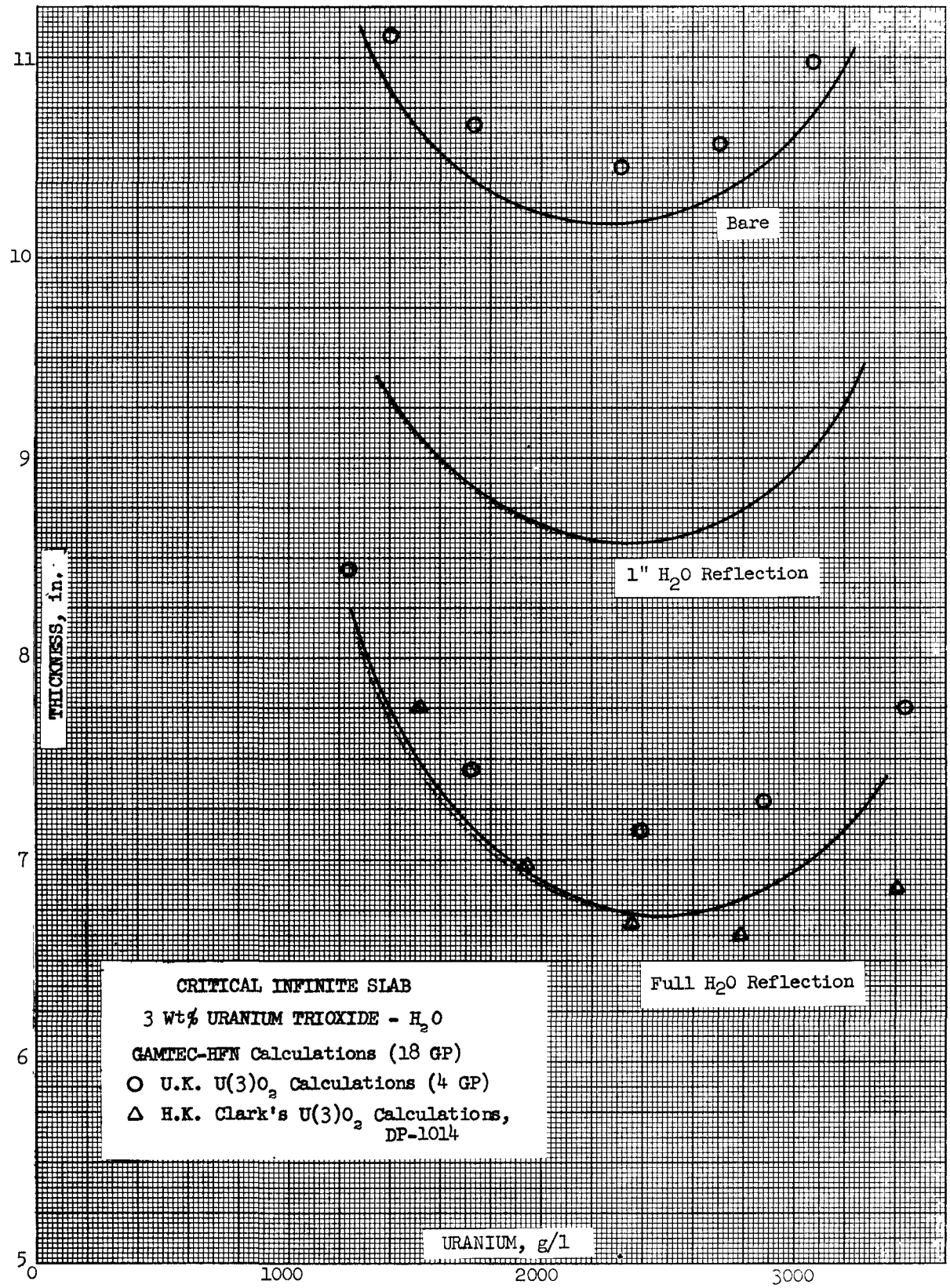

URANIUM TRIOXIDE - H_2O
URANIUM CONCENTRATION
vs. H/U + 1
From ISO-SA-4
H/U + 1
1000
700
500
300
100
70
50
30
10
7
5
3
1
URANIUM, g/l
10
30
50
70
100
300
500
700
1000
3000
5000

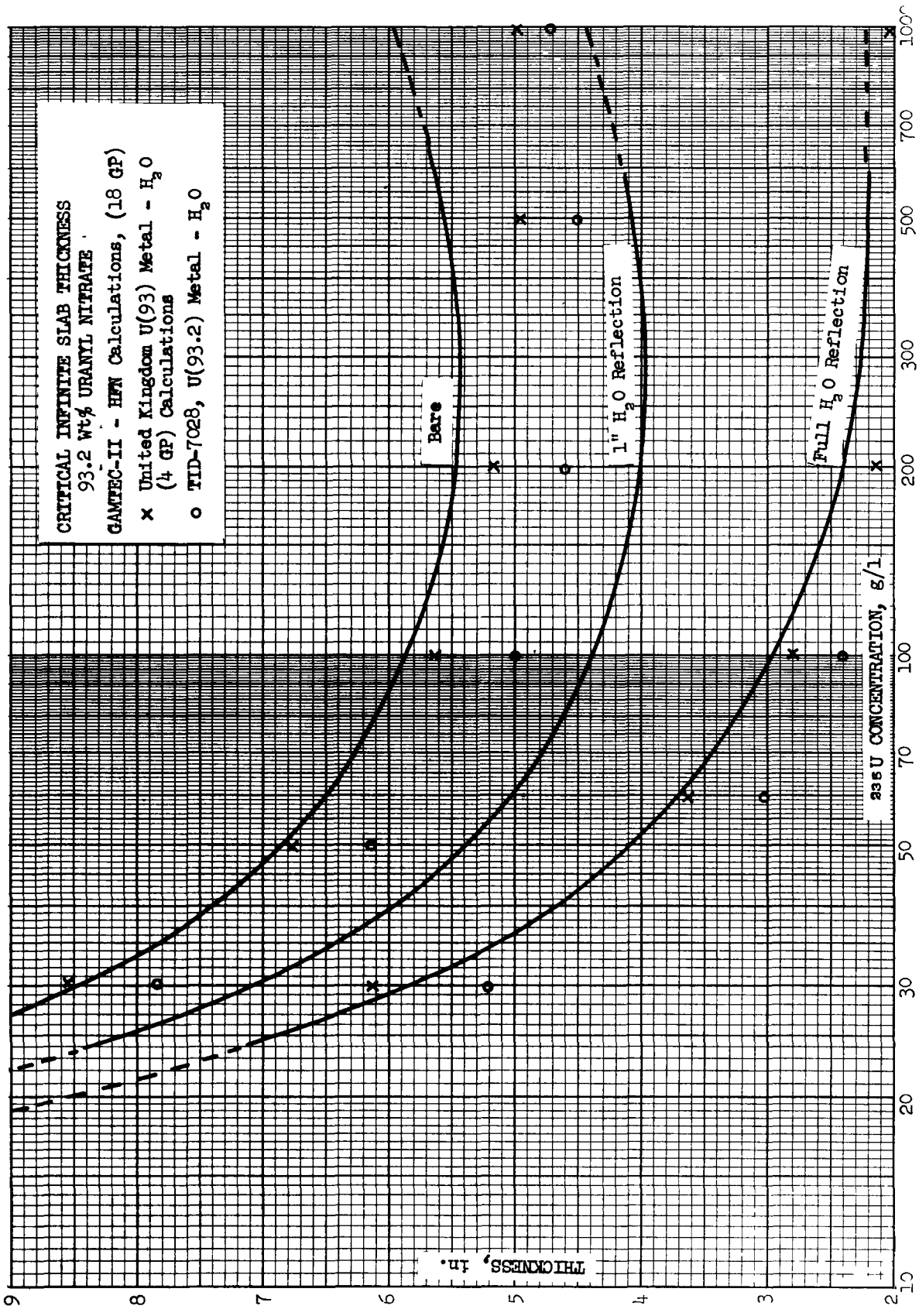

CRITICAL SPHERE RADIUS
3 wt% URANIUM TRIOXIDE
GAMTEC-II-HFN Calculations
(18GP)
BARE
1" H_2O REFLECTION
FULL N_2O REFLECTION
SPHERE RADIUS, in.
URANIUM, g/l
13
12
11
10
9
100
300
500
700
1000
3000
5000

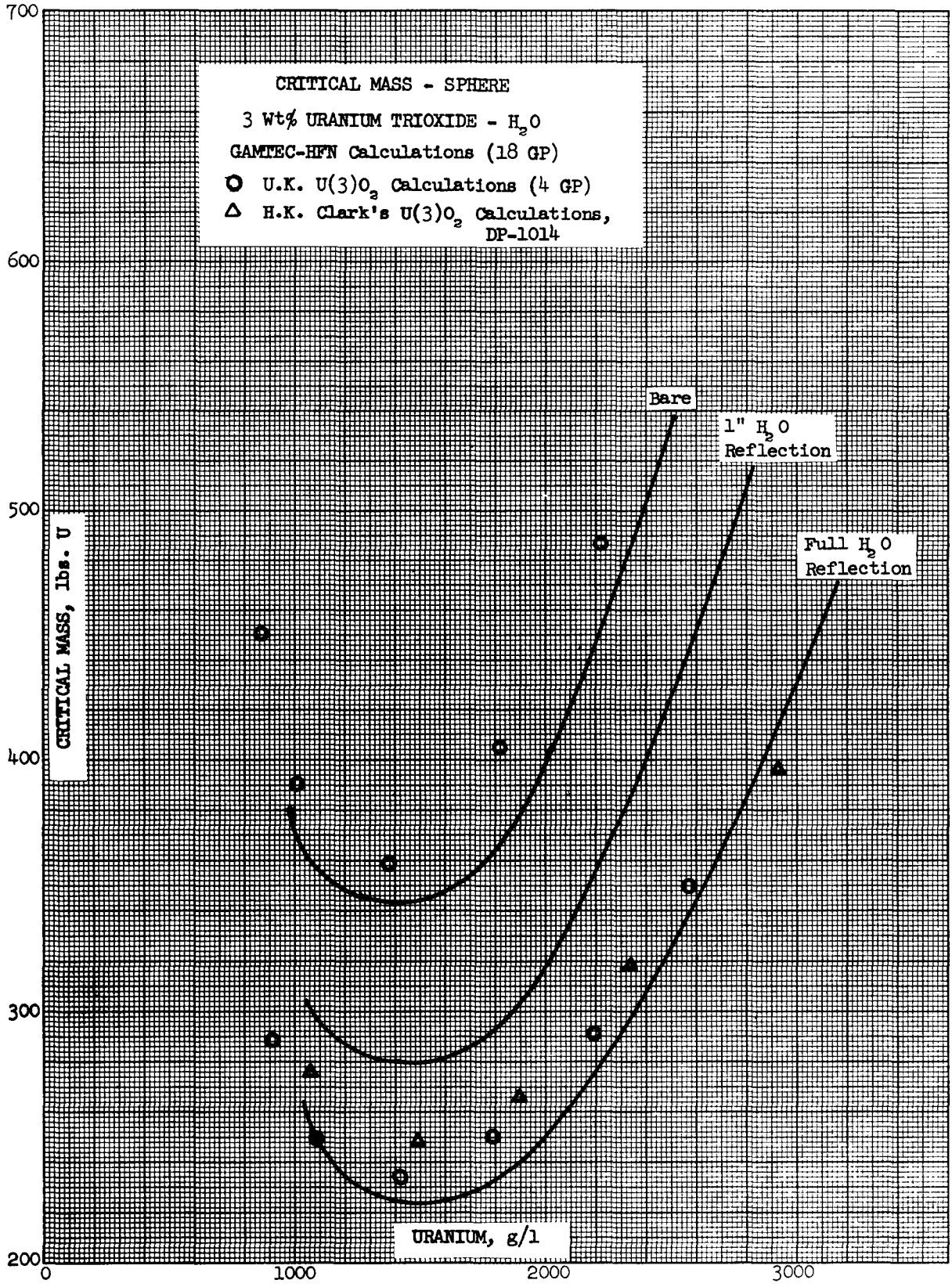

CRITICAL SPHERE RADIUS
93.2 Wt% URANYL NITRATE
GAMTEC-HFN Calculations (18 GP)
Bare
1" H_2O Reflection
Full H_2O Reflection
^{235}U CONCENTRATION, g/l
RADIUS, in.
10
9
8
7
6
5
700
500
300
100
70
50
30
10


18
17
16
15
14
13
12
DIAMETER, in.
0
1000
2000
3000
URANIUM CONCENTRATION, g/l
Bare
1" H_2O Reflection
Full H_2O Reflection
CRITICAL INFINITE CYLINDER DIAMETER
$U(3)O_3$ - H_2O
GAMTEC-HFN Calculations (18 GP)
U.K. $U(3)O_2$ Calculations (4 GP)
H.K. Clark's $U(3)O_2$ Calculations, DP-1014

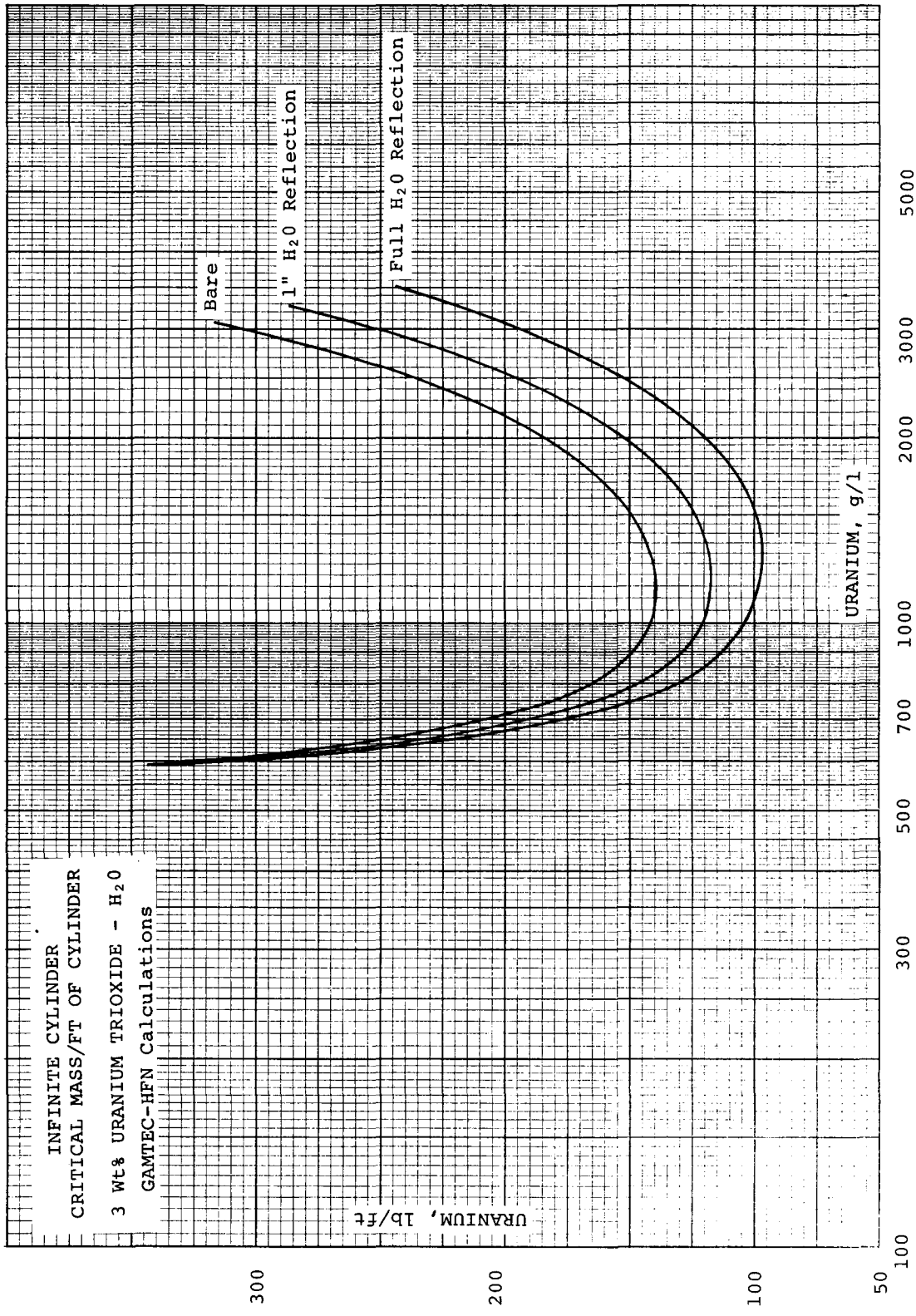

CRITICAL INFINITE CYLINDER DIAMETER
93.2 Wt% URANYL NITRATE
GAMTEC-II - HFN Calculations (18 GP)
× United Kingdom (4 GP) Calculations, U(93) Metal - H_2O
o TID-7028, U(93.2) Metal - H_2O
Bare
1" H_2O Reflection
Full H_2O Reflection
DIAMETER, in.
^{235}U CONCENTRATION, g/l
13
12
11
10
9
8
7
6
10
20
30
50
70
100
200
300
500
700
1000

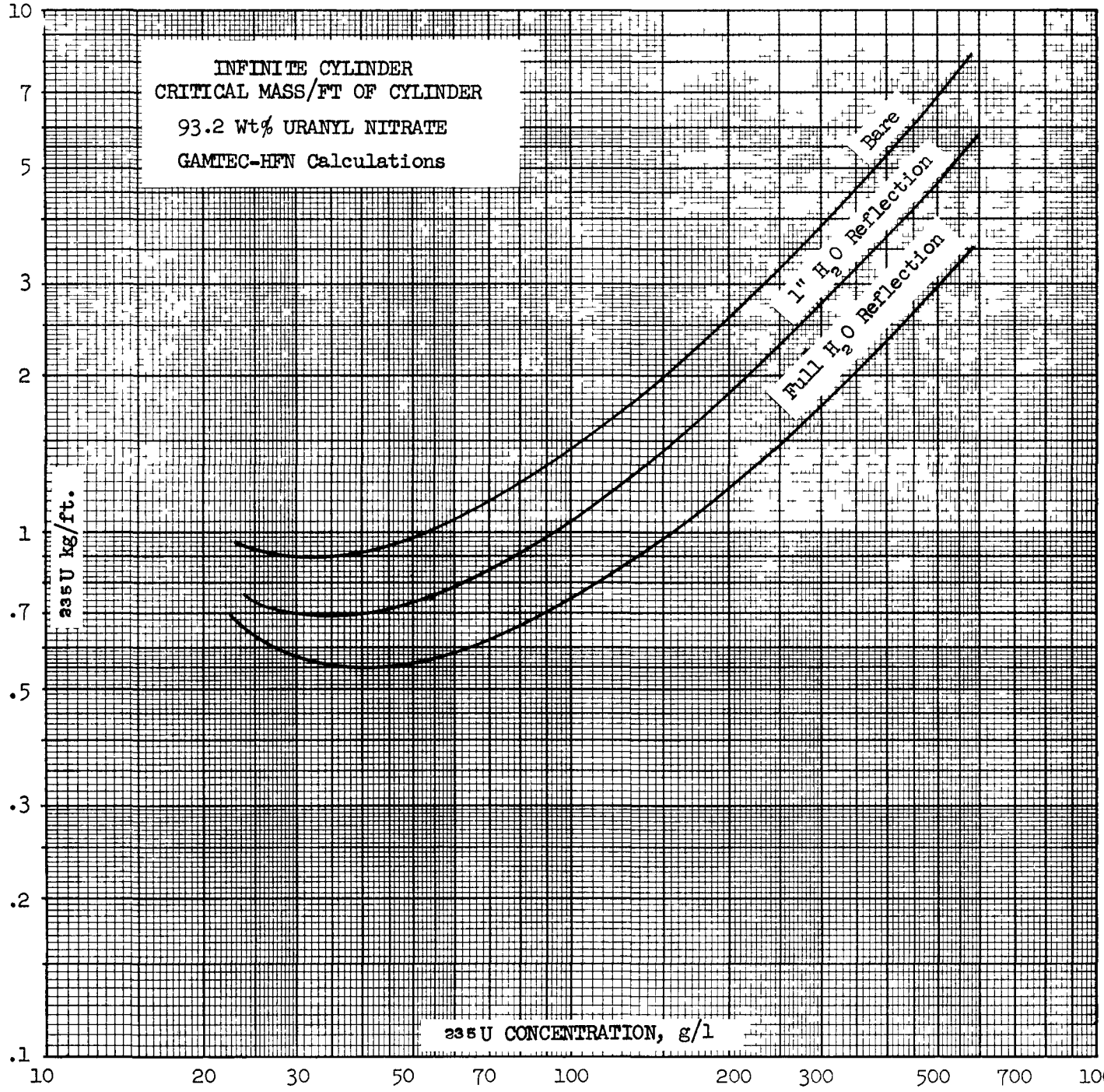

THICKNESS, in.
11
10
9
8
7
6
5
0
1000
2000
3000
URANIUM, g/l
Bare
1" H2O Reflection
Full H2O Reflection
CRITICAL INFINITE SLAB
3 Wt% URANIUM TRIOXIDE - H2O
GAMTEC-HFN Calculations (18 GP)
O U.K. U(3)O2 Calculations (4 GP)
Δ H.K. Clark's U(3)O2 Calculations, DP-1014

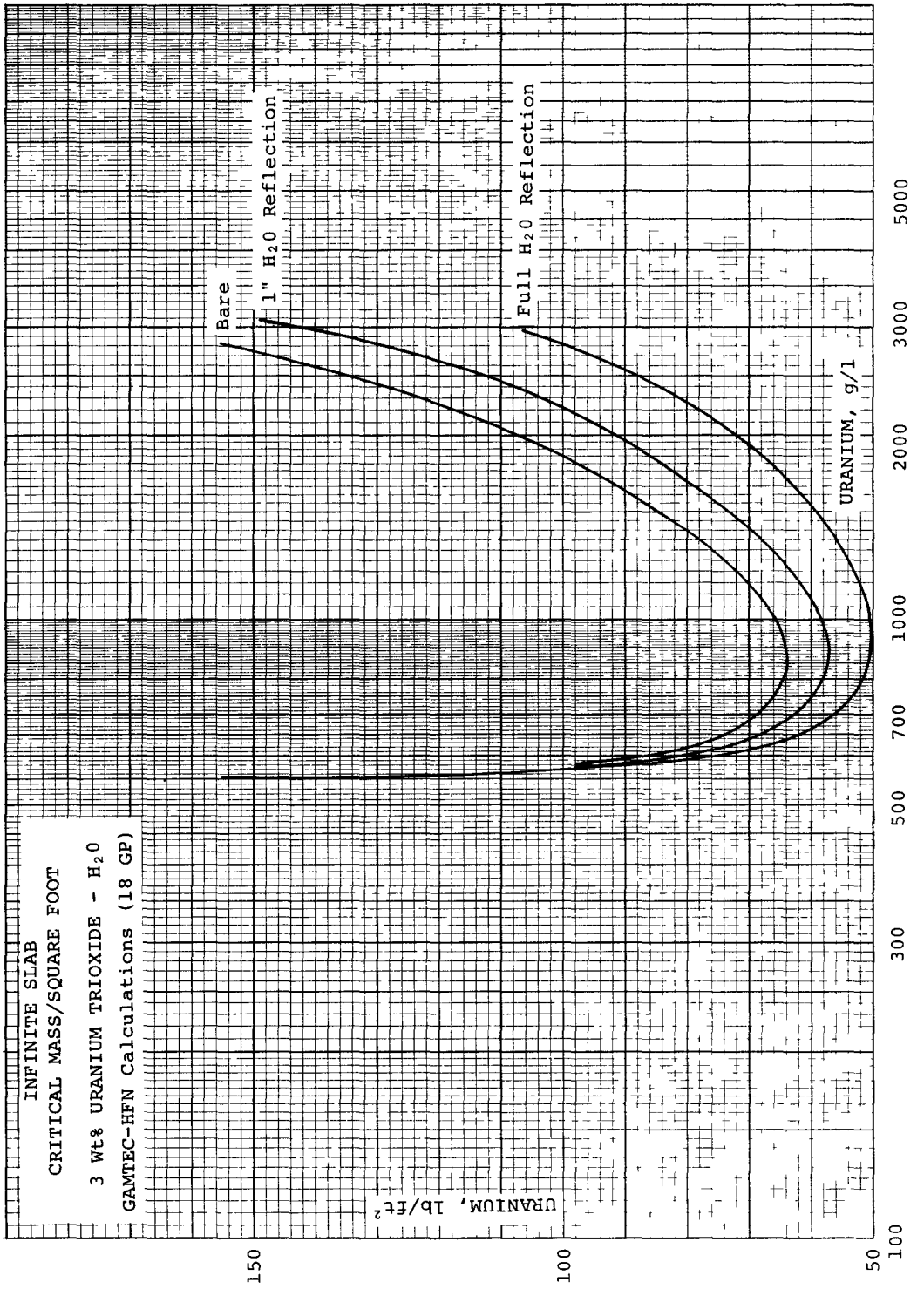

CRITICAL INFINITE SLAB THICKNESS
93.2 wt% URANYL NITRATE
GAMTEC-II - HFN Calculations, (18 GP)
× United Kingdom U(93) Metal - H_2O
(4 GP) Calculations
o TID-7028, U(93.2) Metal - H_2O
Bare
1" H_2O Reflection
Full H_2O Reflection
THICKNESS, in.
^{235}U CONCENTRATION, g/l
9
8
7
6
5
4
3
2
1
100
70
50
30
20
10
700
500
300
200
100

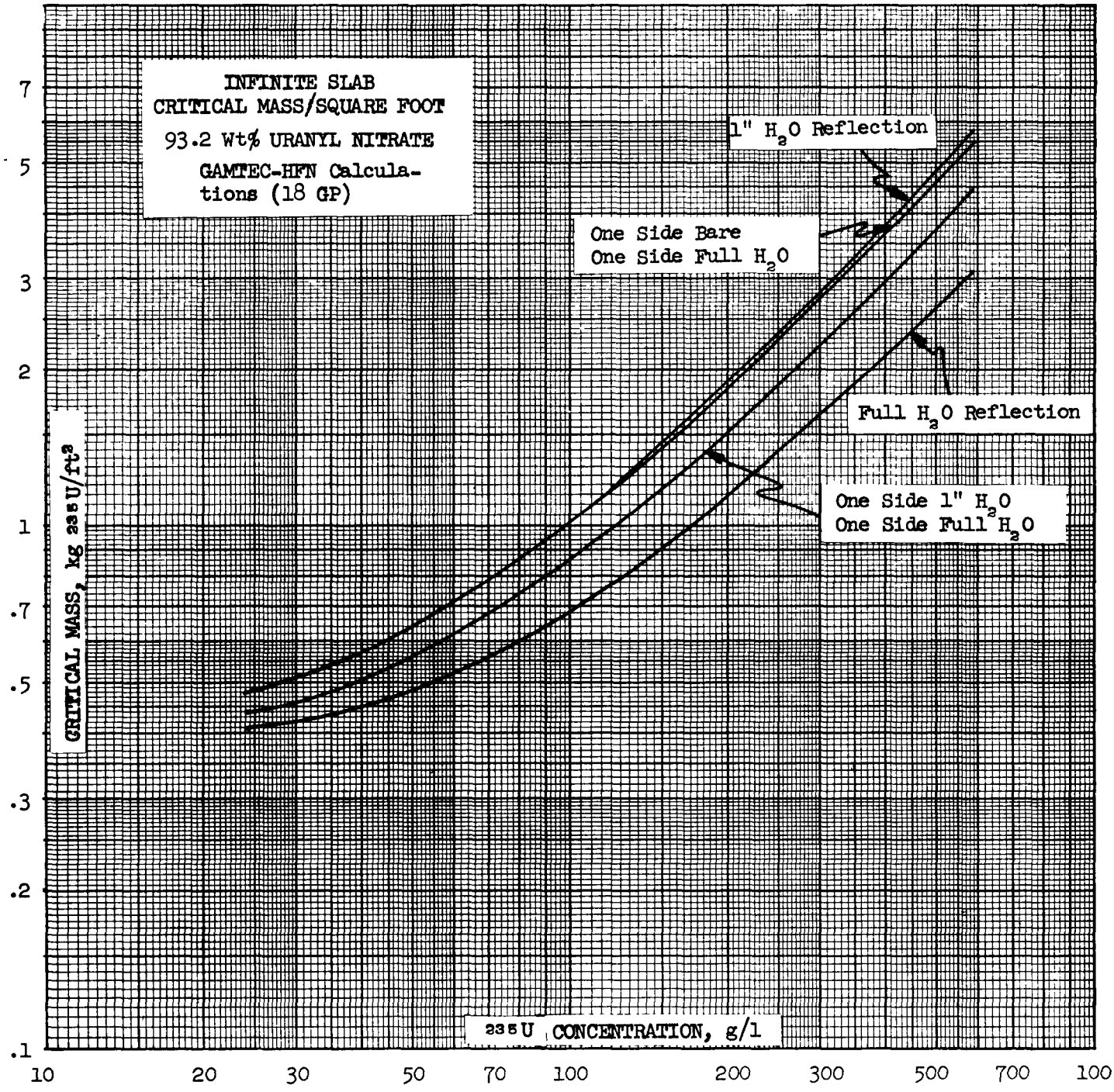

CRITICAL MASS - SPHERE
3 Wt% URANIUM TRIOXIDE - H_2O
GAMTEC-HFN Calculations (18 GP)
U.K. $U(3)O_2$ Calculations (4 GP)
H.K. Clark's $U(3)O_2$ Calculations, DP-1014
Bare
1" H_2O Reflection
Full H_2O Reflection
CRITICAL MASS, lbs. U
URANIUM, g/l
700
600
500
400
300
200
0
1000
2000
3000

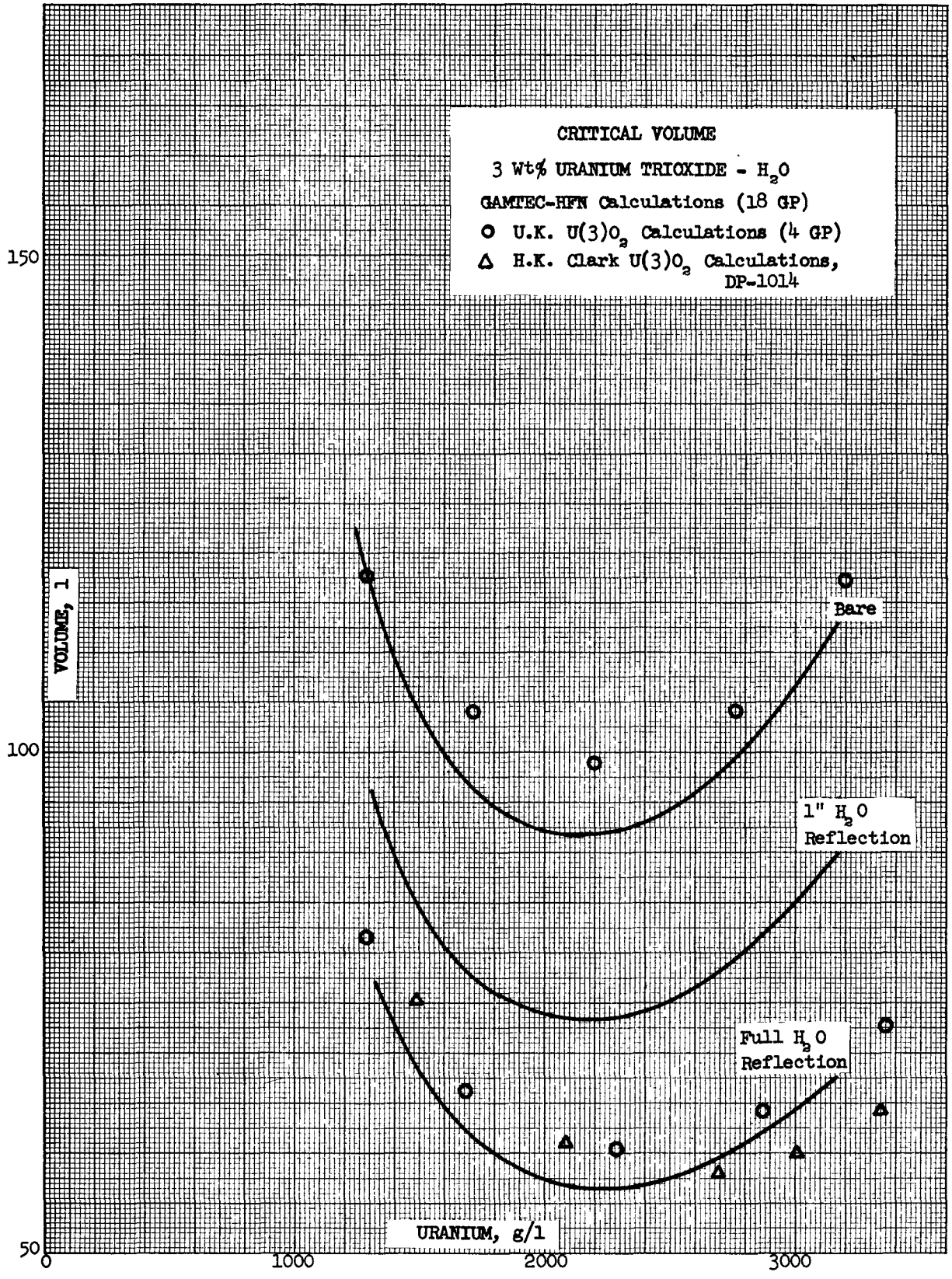
CRITICAL MASS - SPHERE
93.2 Wt% URANYL NITRATE
GAMTEC-II - HFN Calculations (18 GP)
× United Kingdom (4 GP) Calculations, U(93) Metal - H2O
o TID-7028, U(93.2) Metal - H2O
Bare
1" H2O Reflection
Full H2O Reflection
CRITICAL MASS, kg 235U
235U CONCENTRATION, g/l
0
1
2
3
4
5
6
7
8
9
10
11
12
10
20
30
50
70
100
200
300
500
700
1000

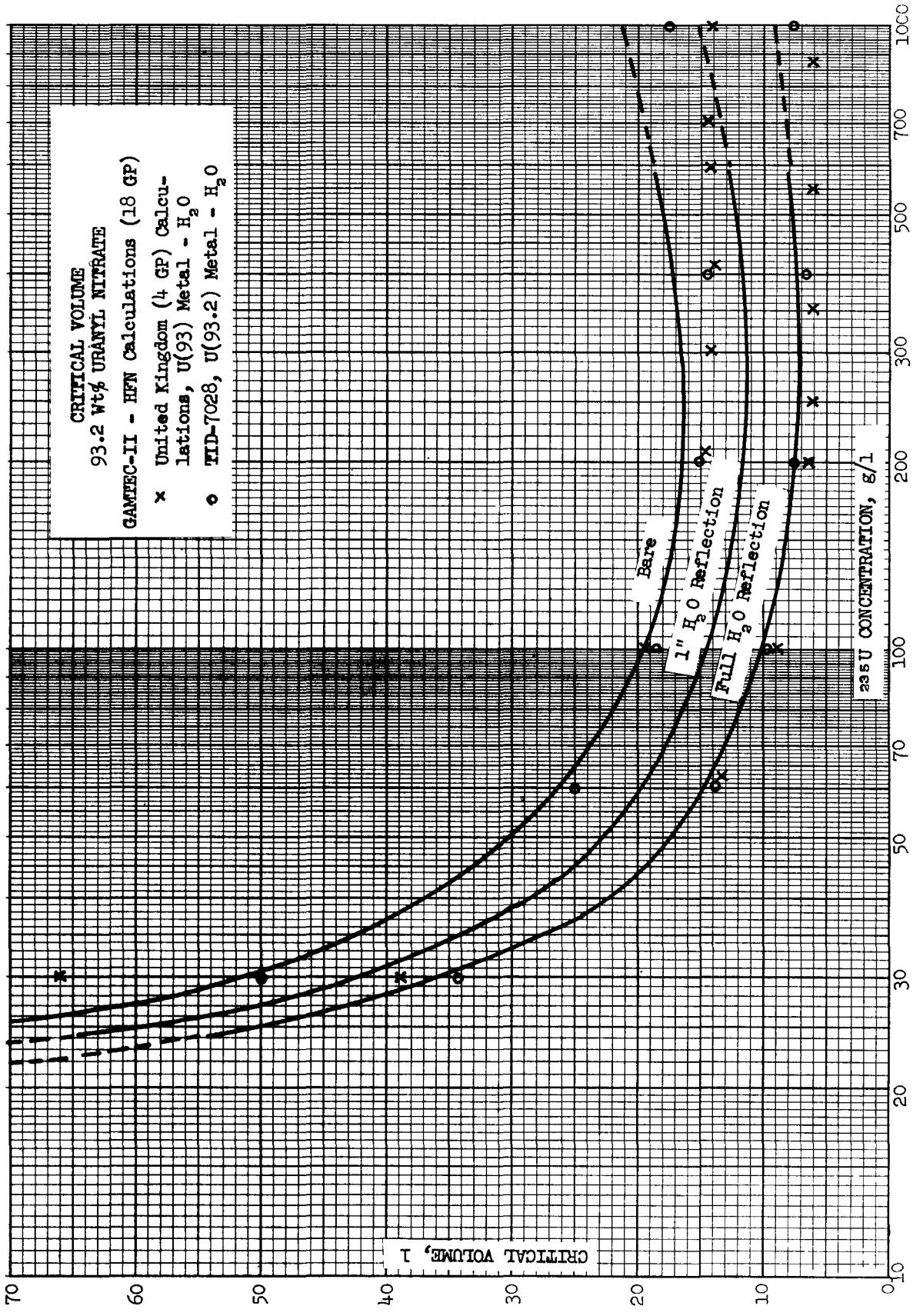

INFINITE CYLINDER
CRITICAL MASS/FT OF CYLINDER
3 Wt% URANIUM TRIOXIDE - H_2O
GAMTEC-HFN Calculations
Bare
1" H_2O Reflection
Full H_2O Reflection
URANIUM, lb/ft
300
200
100
50
URANIUM, g/l
100
300
500
700
1000
2000
3000
5000

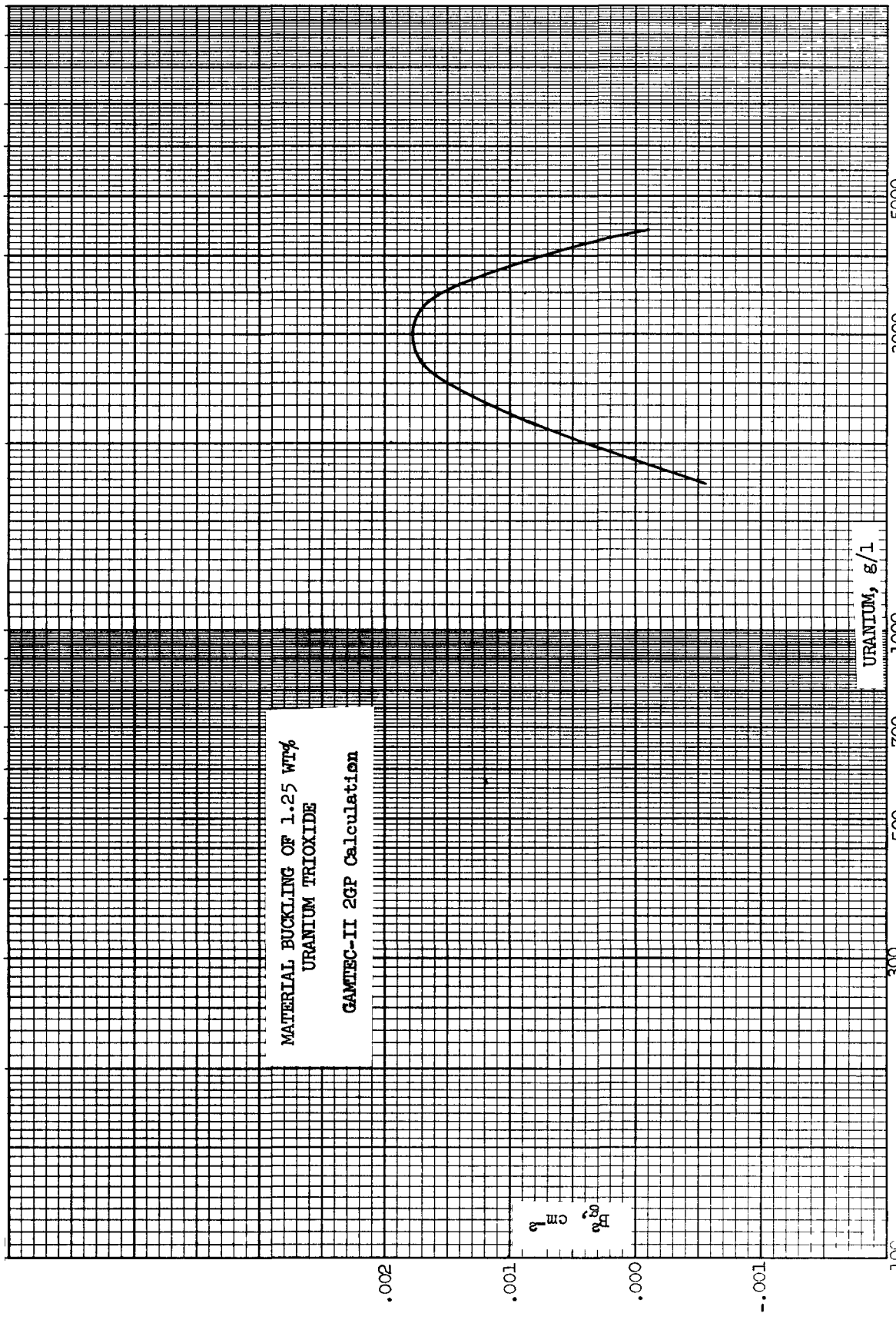

INFINITE CYLINDER
CRITICAL MASS/FT OF CYLINDER
93.2 Wt% URANYL NITRATE
GAMTEC-HFN Calculations
Bare
1" H2O Reflection
Full H2O Reflection
235U kg/ft.
235U CONCENTRATION, g/l
10
7
5
3
2
1
.7
.5
.3
.2
.1
10
20
30
50
70
100
200
300
500
700
1000

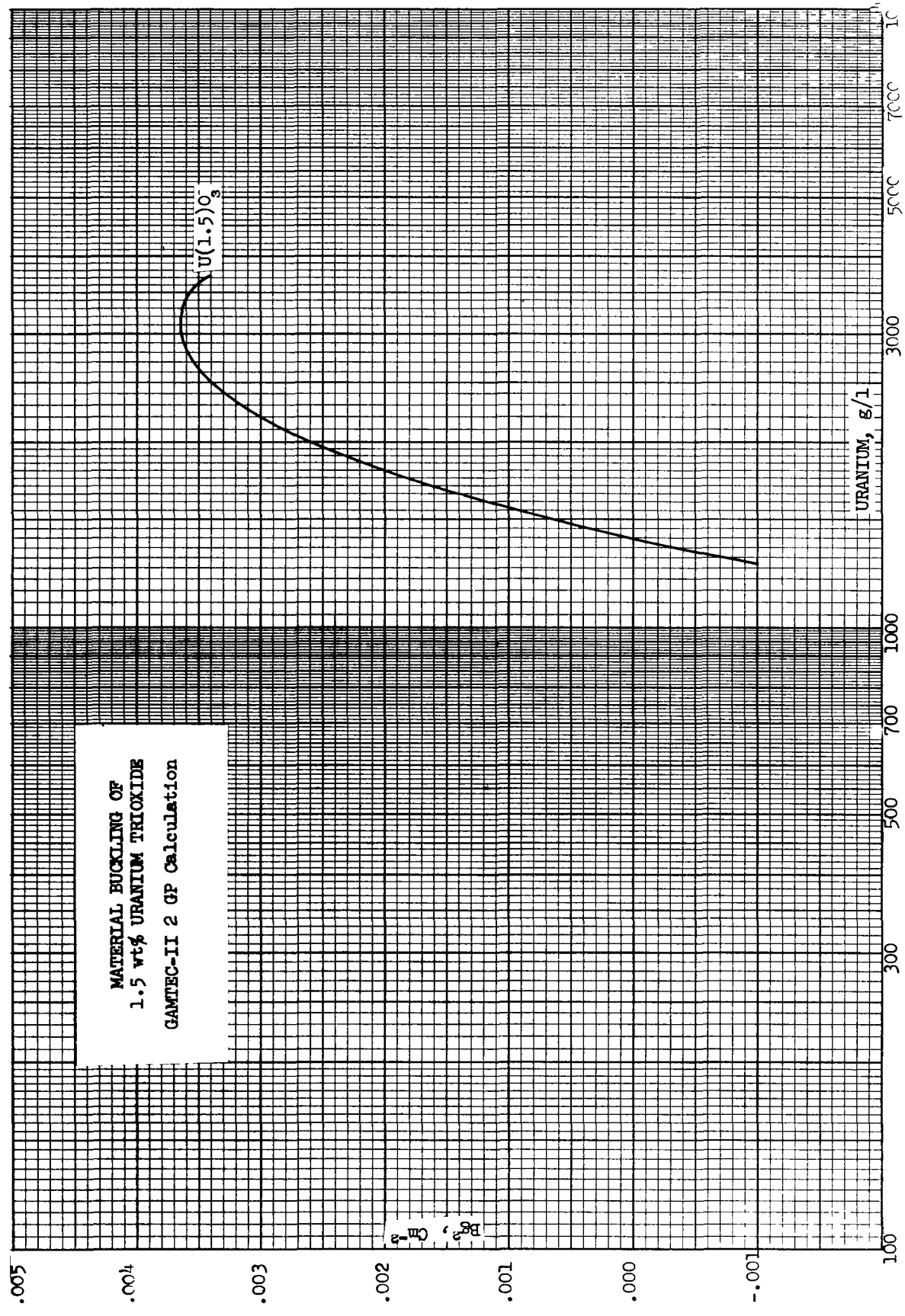

INFINITE SLAB
CRITICAL MASS/SQUARE FOOT
3 Wt% URANIUM TRIOXIDE - H_2O
GAMTEC-HFN Calculations (18 GP)
Bare
1" H_2O Reflection
Full H_2O Reflection
URANIUM, lb/ft^2
URANIUM, g/l
150
100
50
100
300
500
700
1000
2000
3000
5000

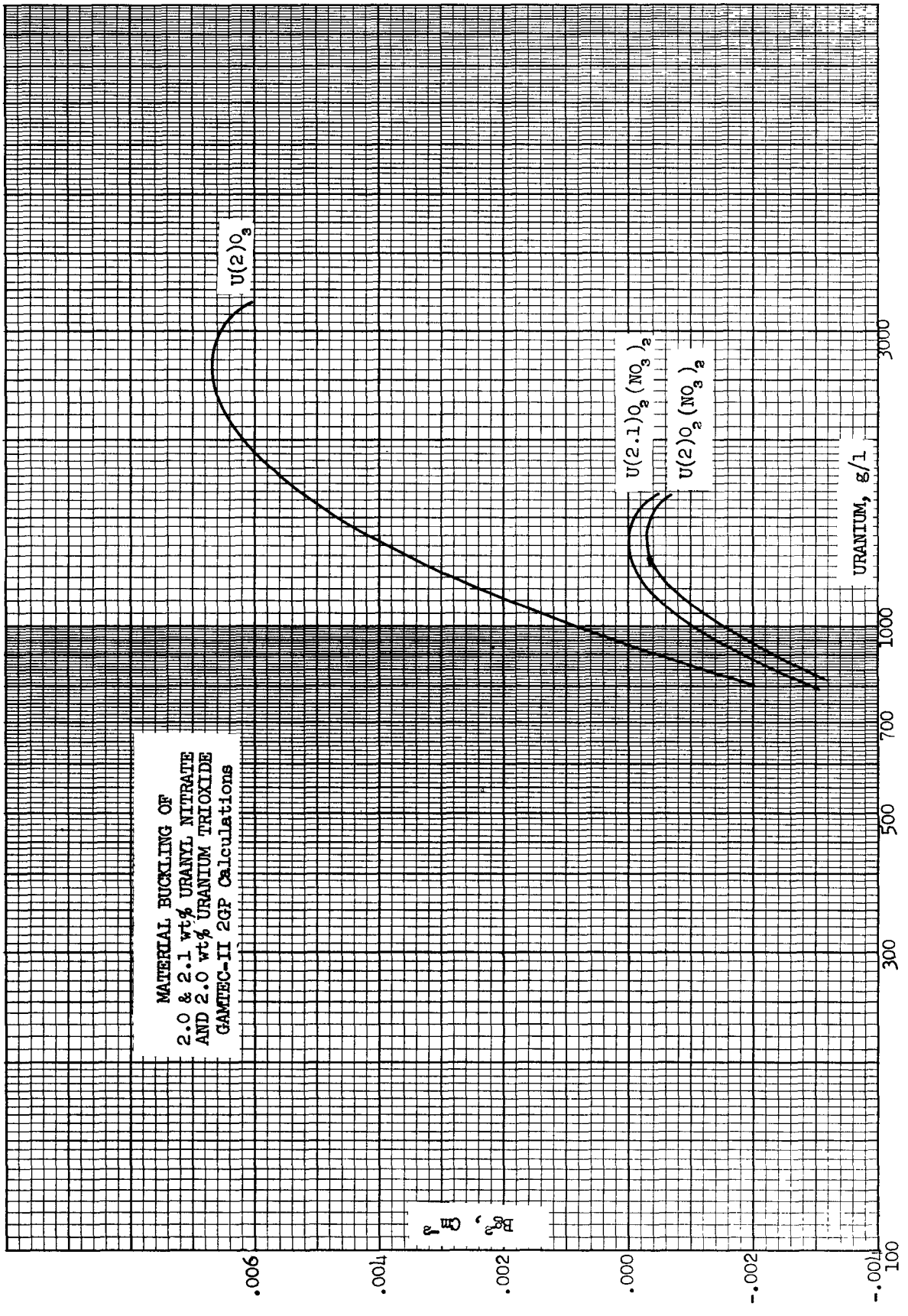

INFINITE SLAB
CRITICAL MASS/SQUARE FOOT
93.2 Wt% URANYL NITRATE
GAMTEC-HFN Calculations (18 GP)
1" H2O Reflection
One Side Bare
One Side Full H2O
Full H2O Reflection
One Side 1" H2O
One Side Full H2O
CRITICAL MASS, kg 235U/ft2
235U CONCENTRATION, g/l
7
5
3
2
1
.7
.5
.3
.2
.1
10
20
30
50
70
100
200
300
500
700
100

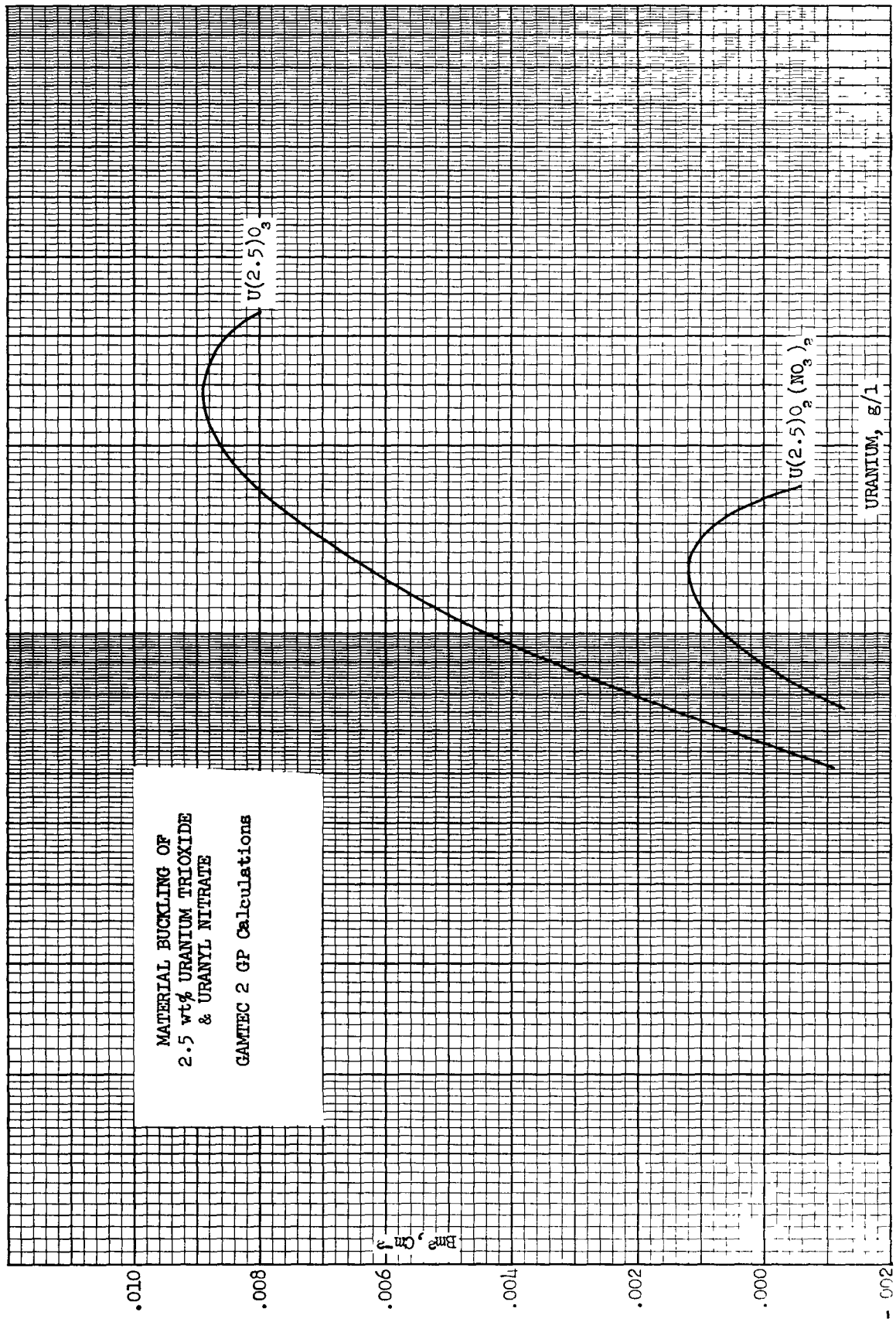

CRITICAL VOLUME
3 Wt% URANIUM TRIOXIDE - H_2O
GAMTEC-HFN Calculations (18 GP)
O U.K. $U(3)O_2$ Calculations (4 GP)
Δ H.K. Clark $U(3)O_2$ Calculations, DP-1014
VOLUME, l
150
100
50
0
1000
2000
3000
URANIUM, g/l
Bare
1" H_2O Reflection
Full H_2O Reflection

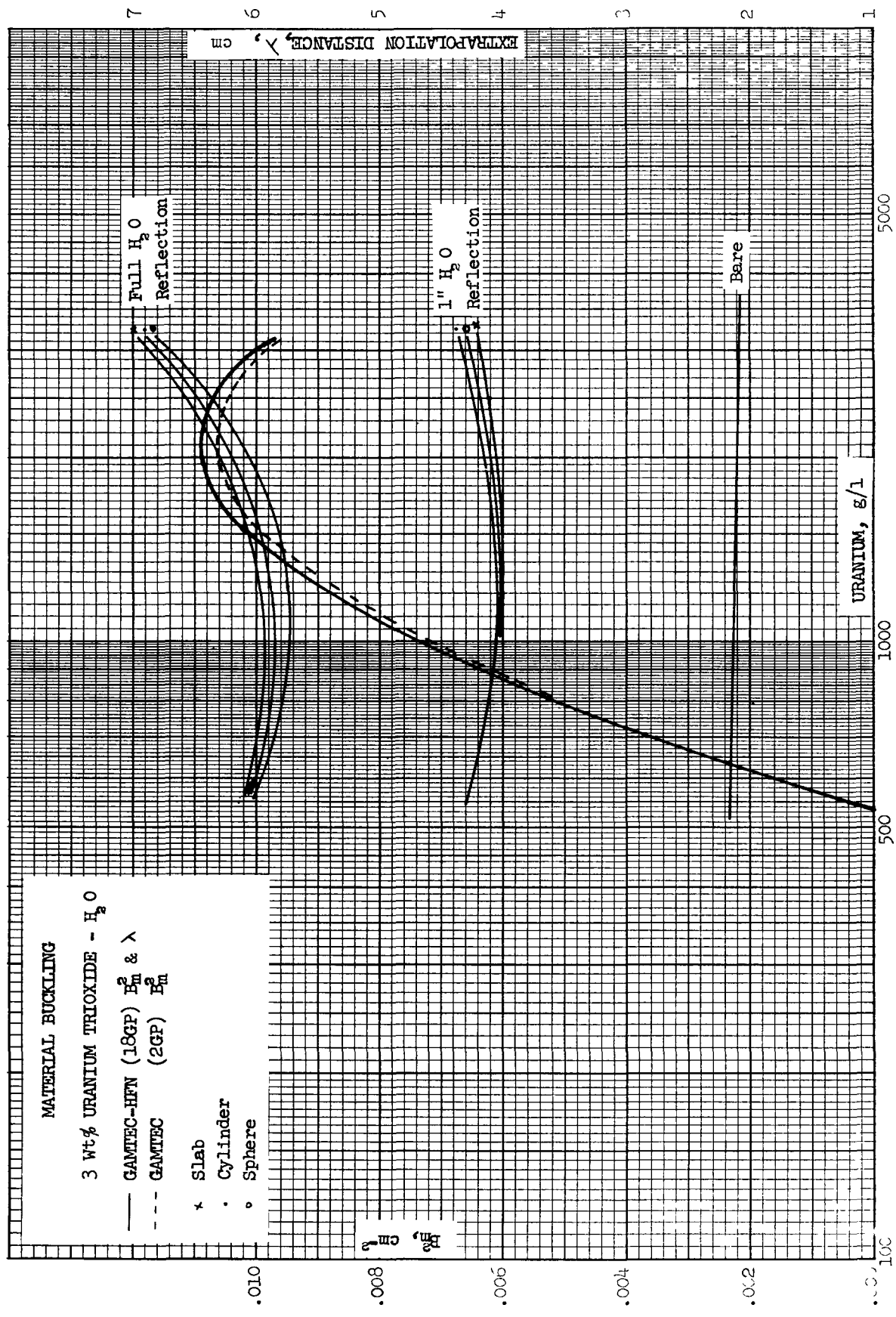

CRITICAL VOLUME
93.2 Wt% URANYL NITRATE
GAMTEC-II - HFN Calculations (18 GP)
× United Kingdom (4 GP) Calculations, U(93) Metal - H_2O
○ TID-7028, U(93.2) Metal - H_2O
Bare
1" H_2O Reflection
Full H_2O Reflection
^{235}U CONCENTRATION, g/l
CRITICAL VOLUME, l
1000
700
500
300
200
100
70
50
30
20
10
70
60
50
40
30
20
10
0

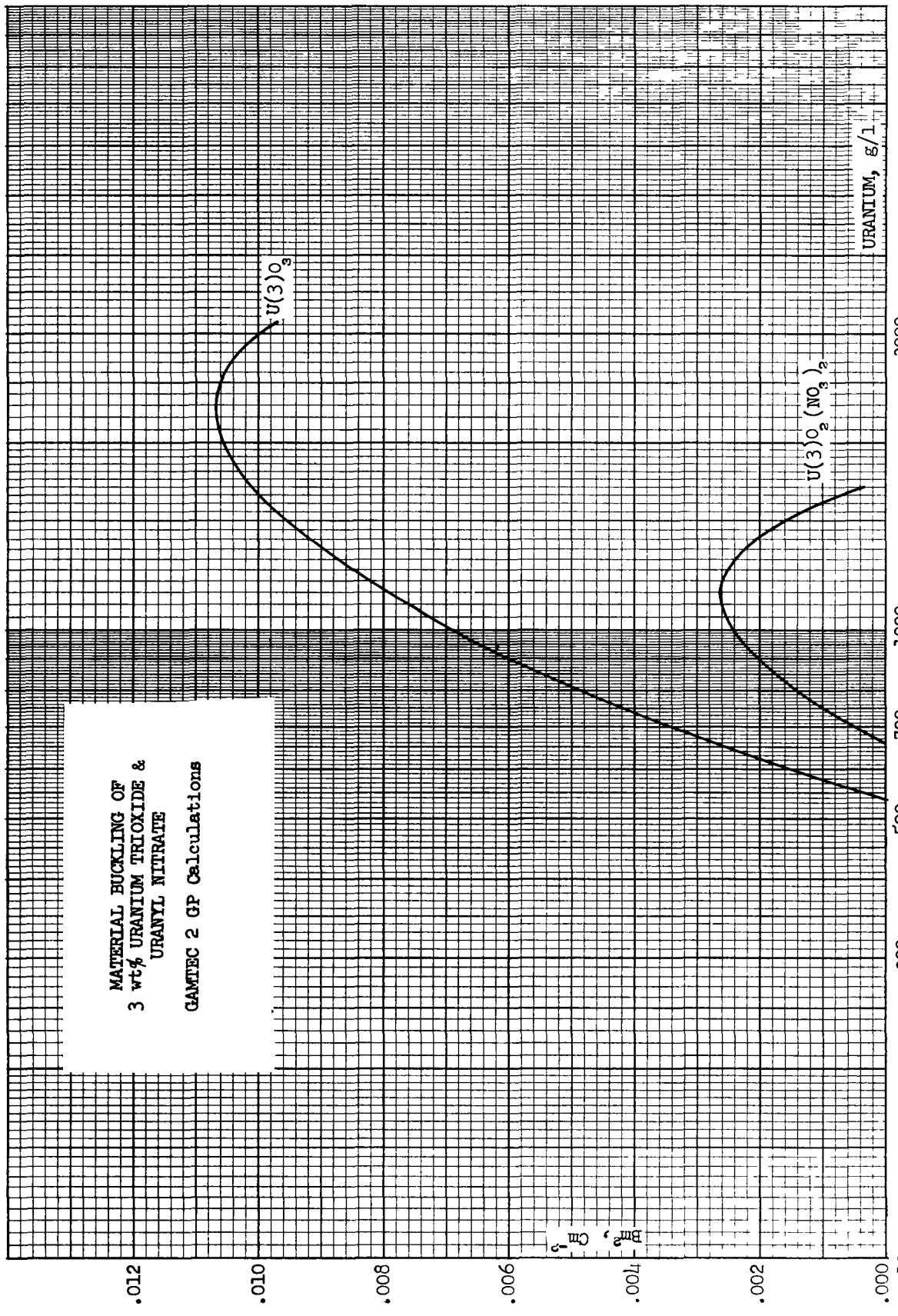

MATERIAL BUCKLING OF 1.25 WT% URANIUM TRIOXIDE
GAMTEC-II 2GP Calculation
B_g^2, cm^{-2}
.002
.001
.000
-.001
URANIUM, g/l
100
300
500
700
1000
3000
5000

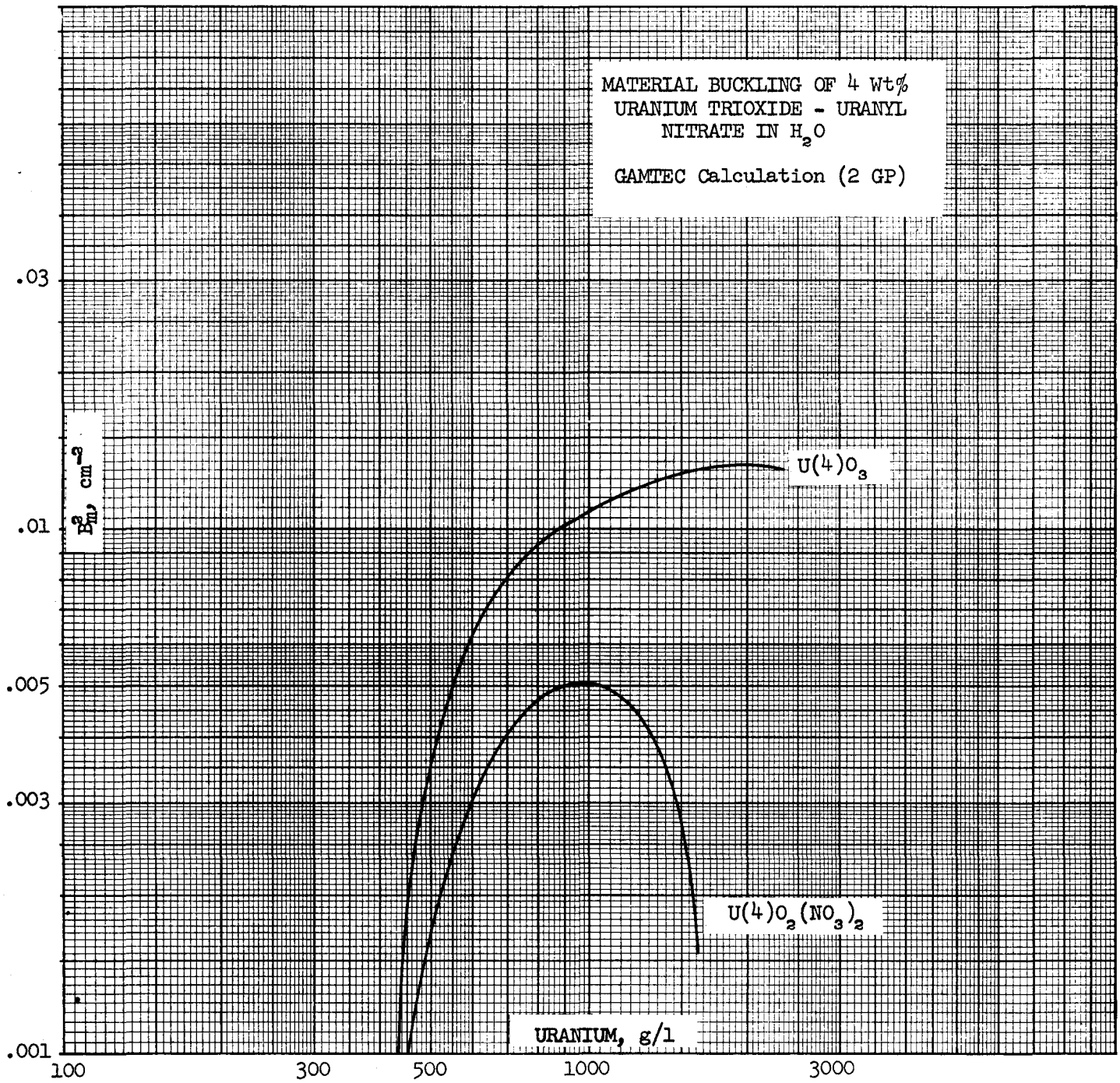

MATERIAL BUCKLING OF
1.5 wt% URANIUM TRIOXIDE
GAMTEC-II 2 GP Calculation
U(1.5)O3
URANIUM, g/l
B2, cm-2
.005
.004
.003
.002
.001
.000
-.001
100
300
500
700
1000
3000
5000
7000

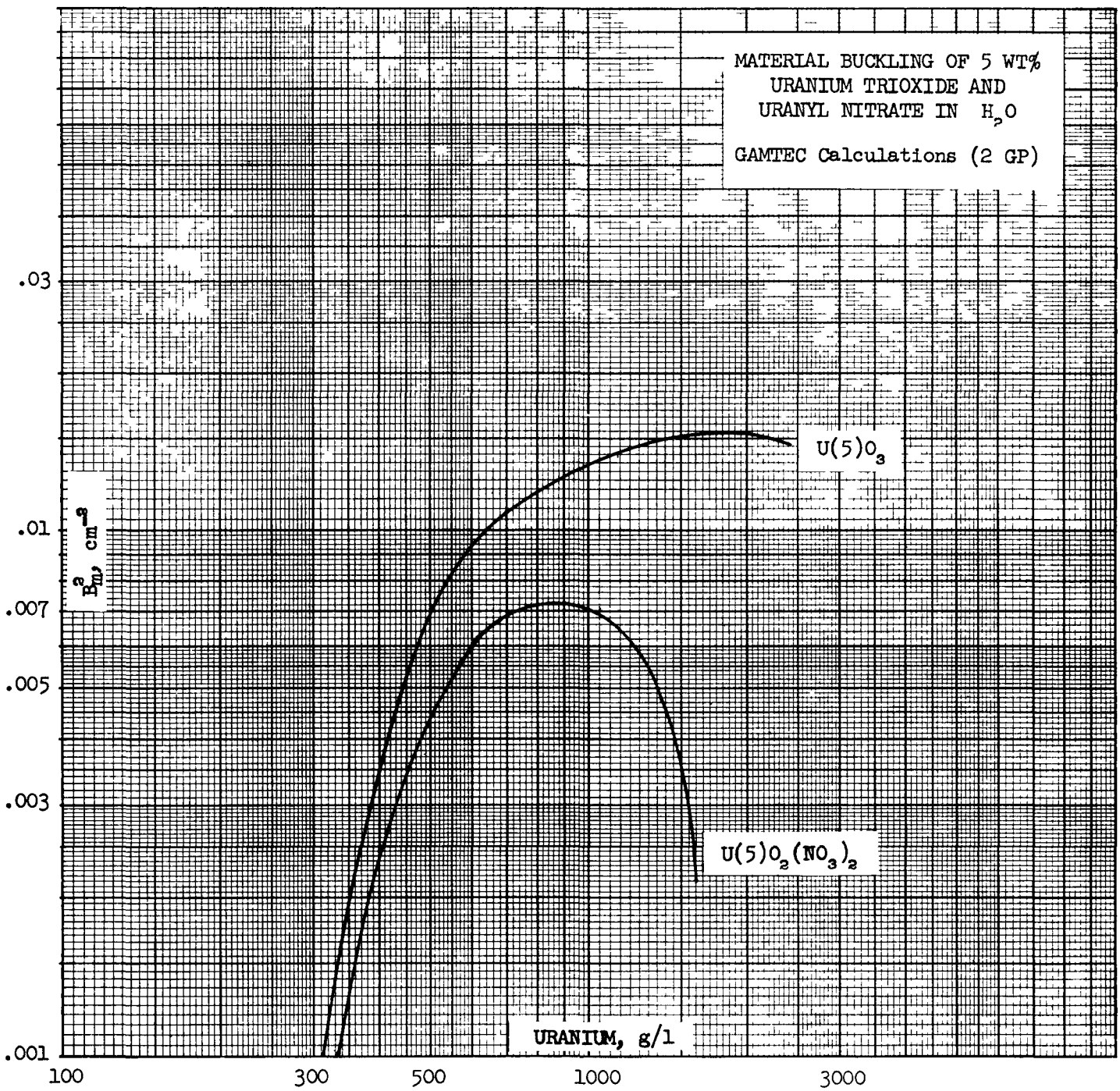

MATERIAL BUCKLING OF
2.0 & 2.1 wt% URANYL NITRATE
AND 2.0 wt% URANIUM TRIOXIDE
GAMTEC-II 2GP Calculations
U(2)O3
U(2.1)O2(NO3)2
U(2)O2(NO3)2
URANIUM, g/l
B2, cm-2
100
300
500
700
1000
3000
-.004
-.002
.000
.002
.004
.006

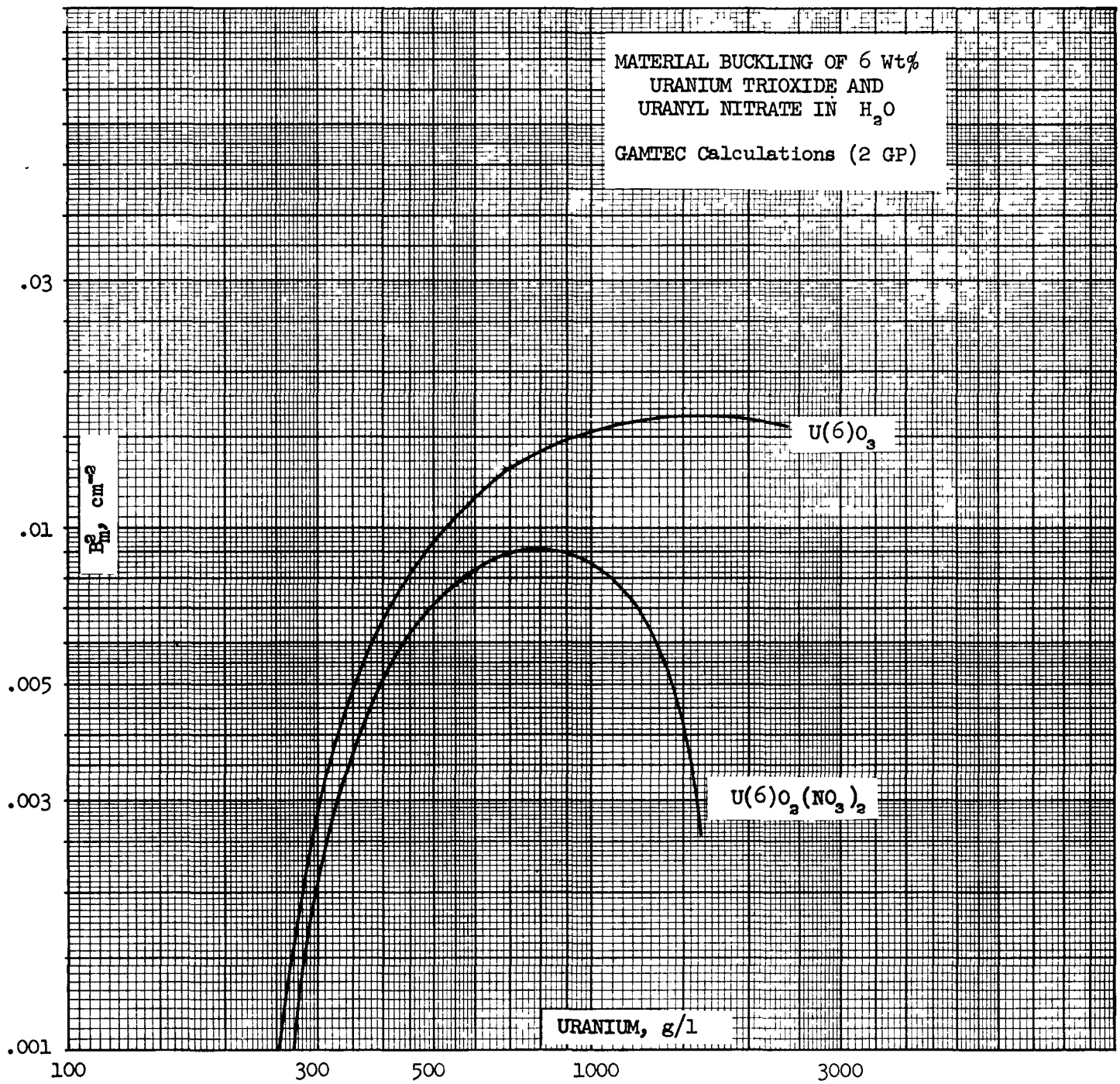

MATERIAL BUCKLING OF
2.5 wt% URANIUM TRIOXIDE
& URANYL NITRATE
GAMTEC 2 GP Calculations
U(2.5)O3
U(2.5)O2(NO3)2
URANIUM, g/l
Bm², Cm⁻²
.010
.008
.006
.004
.002
.000
-.002
100
300
500
700
1000

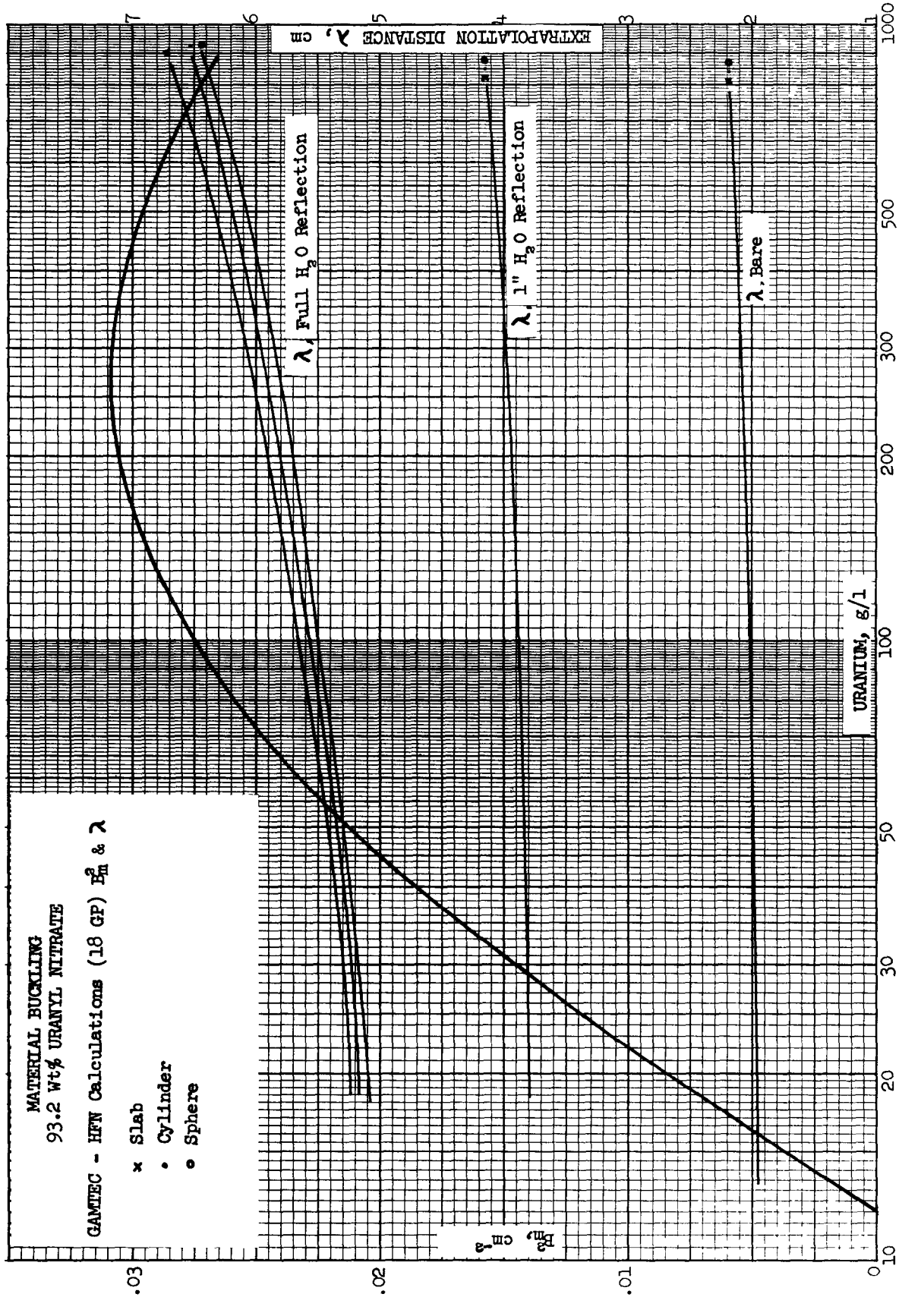

MATERIAL BUCKLING
3 Wt% URANIUM TRIOXIDE - H_2O
—— GAMTEC-HFN (18GP) B_m^2 & λ
- - - GAMTEC (2GP) B_m^2
x Slab
· Cylinder
° Sphere
B_m^2, cm^{-2}
.010
.008
.006
.004
.002
URANIUM, g/l
100
500
1000
5000
EXTRAPOLATION DISTANCE, λ, cm
1
2
3
4
5
6
7
Full H_2O Reflection
1" H_2O Reflection
Bare

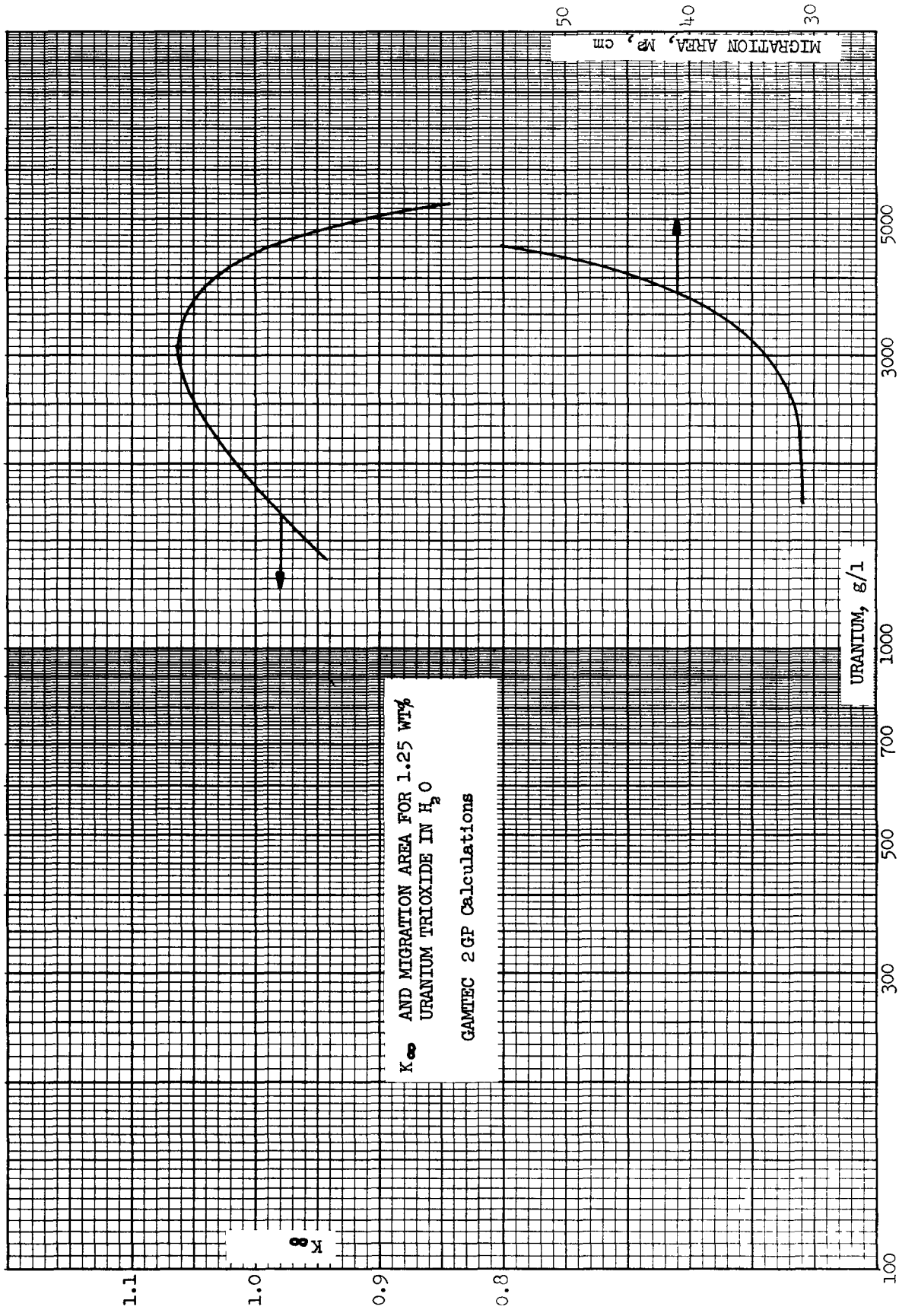

MATERIAL BUCKLING OF
3 wt% URANIUM TRIOXIDE &
URANYL NITRATE
GAMTEC 2 GP Calculations
$U(3)O_3$
$U(3)O_2(NO_3)_2$
URANIUM, g/l
100
300
500
700
1000
3000
.000
.002
.004
.006
.008
.010
.012
B_m^2, cm^{-2}

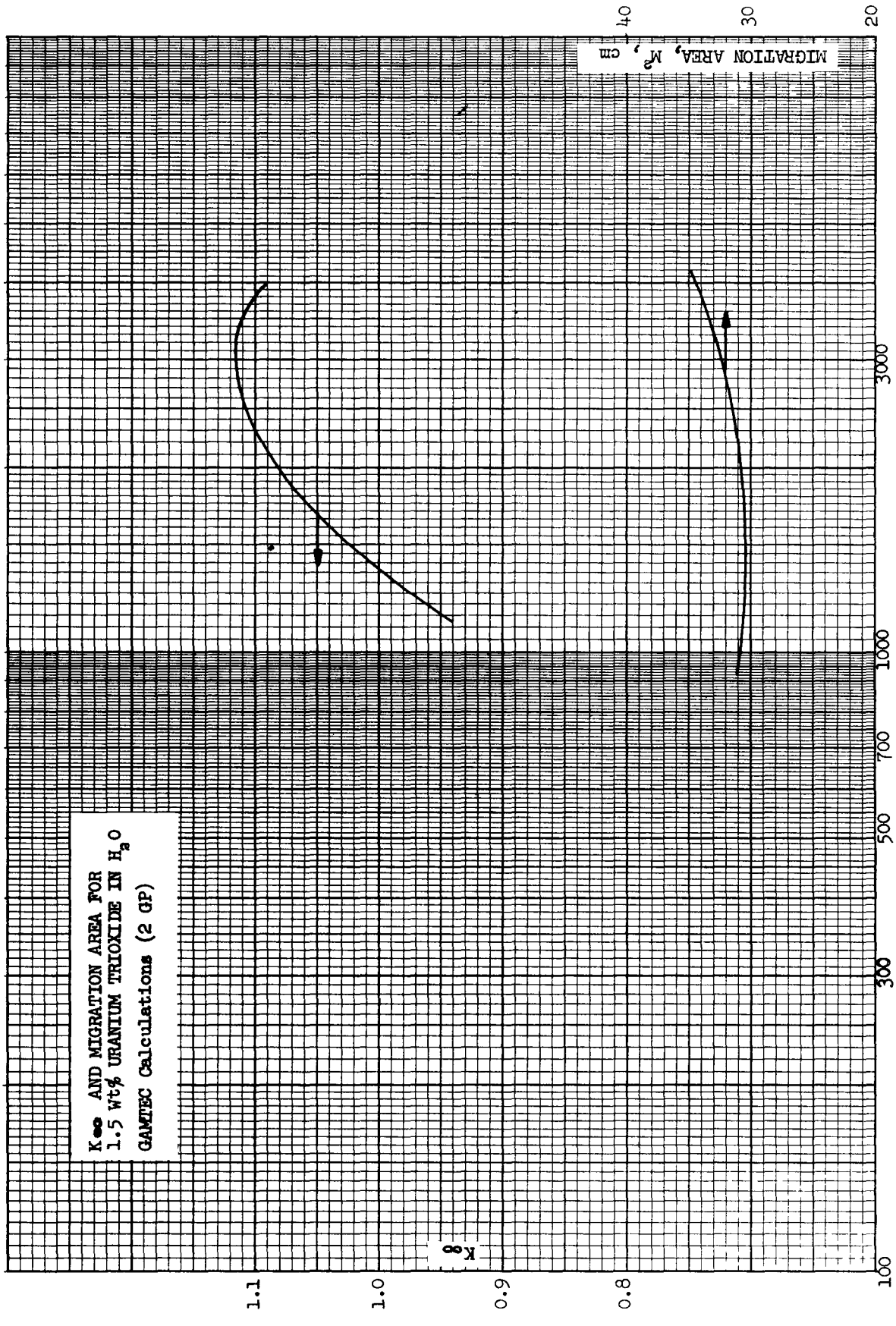

MATERIAL BUCKLING OF 4 Wt% URANIUM TRIOXIDE - URANYL NITRATE IN H_2O
GAMTEC Calculation (2 GP)
B_m^2, cm^{-2}
.03
.01
.005
.003
.001
100
300
500
1000
3000
URANIUM, g/l
$U(4)O_3$
$U(4)O_2(NO_3)_2$

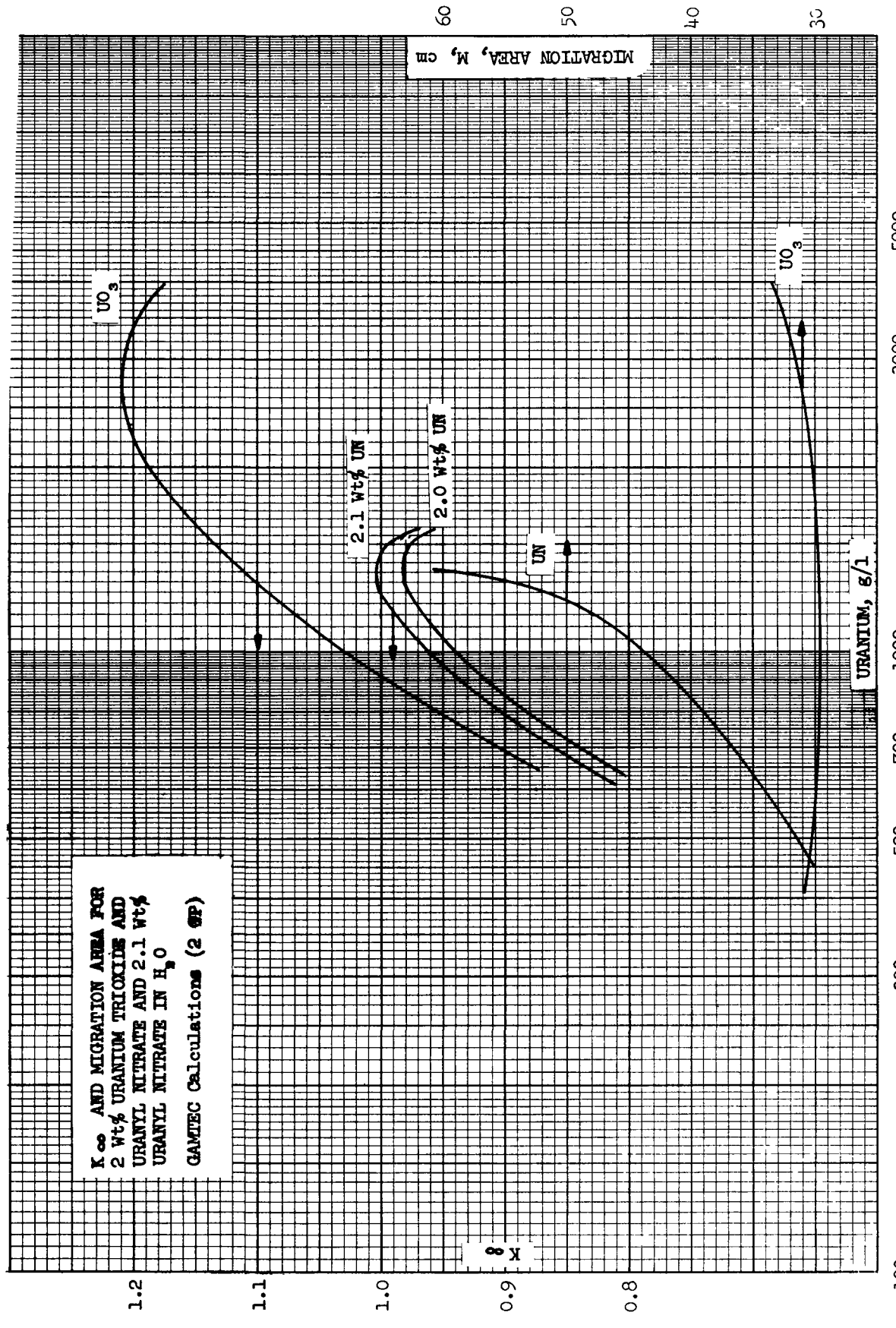

MATERIAL BUCKLING OF 5 WT% URANIUM TRIOXIDE AND URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)
B_m^2, cm^{-2}
.03
.01
.007
.005
.003
.001
100
300
500
1000
3000
URANIUM, g/l
$U(5)O_3$
$U(5)O_2(NO_3)_2$

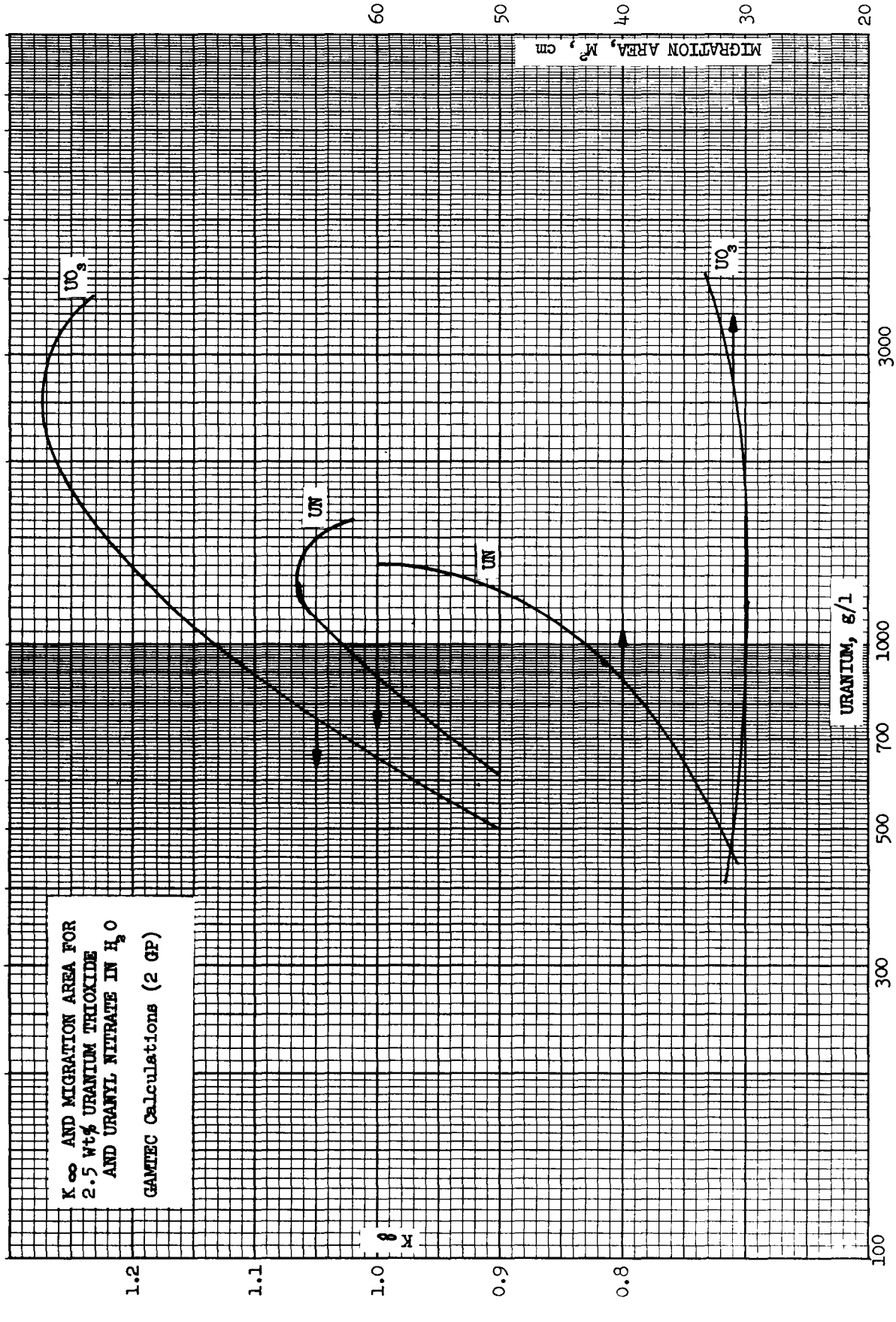

MATERIAL BUCKLING OF 6 Wt% URANIUM TRIOXIDE AND URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)
B_m^2, cm^{-2}
.03
.01
.005
.003
.001
$U(6)O_3$
$U(6)O_2(NO_3)_2$
URANIUM, g/l
100
300
500
1000
3000


MATERIAL BUCKLING
93.2 wt% URANYL NITRATE
GAMTEC - HFN Calculations (18 GP) B_m^2 & λ
× Slab
• Cylinder
• Sphere
λ, Full H_2O Reflection
λ, 1" H_2O Reflection
λ, Bare
EXTRAPOLATION DISTANCE λ, cm
B_m^2, cm^{-2}
URANIUM, g/l
.03
.02
.01
0
10
20
30
50
100
200
300
500
1000
7
6
5
4
3
2
1

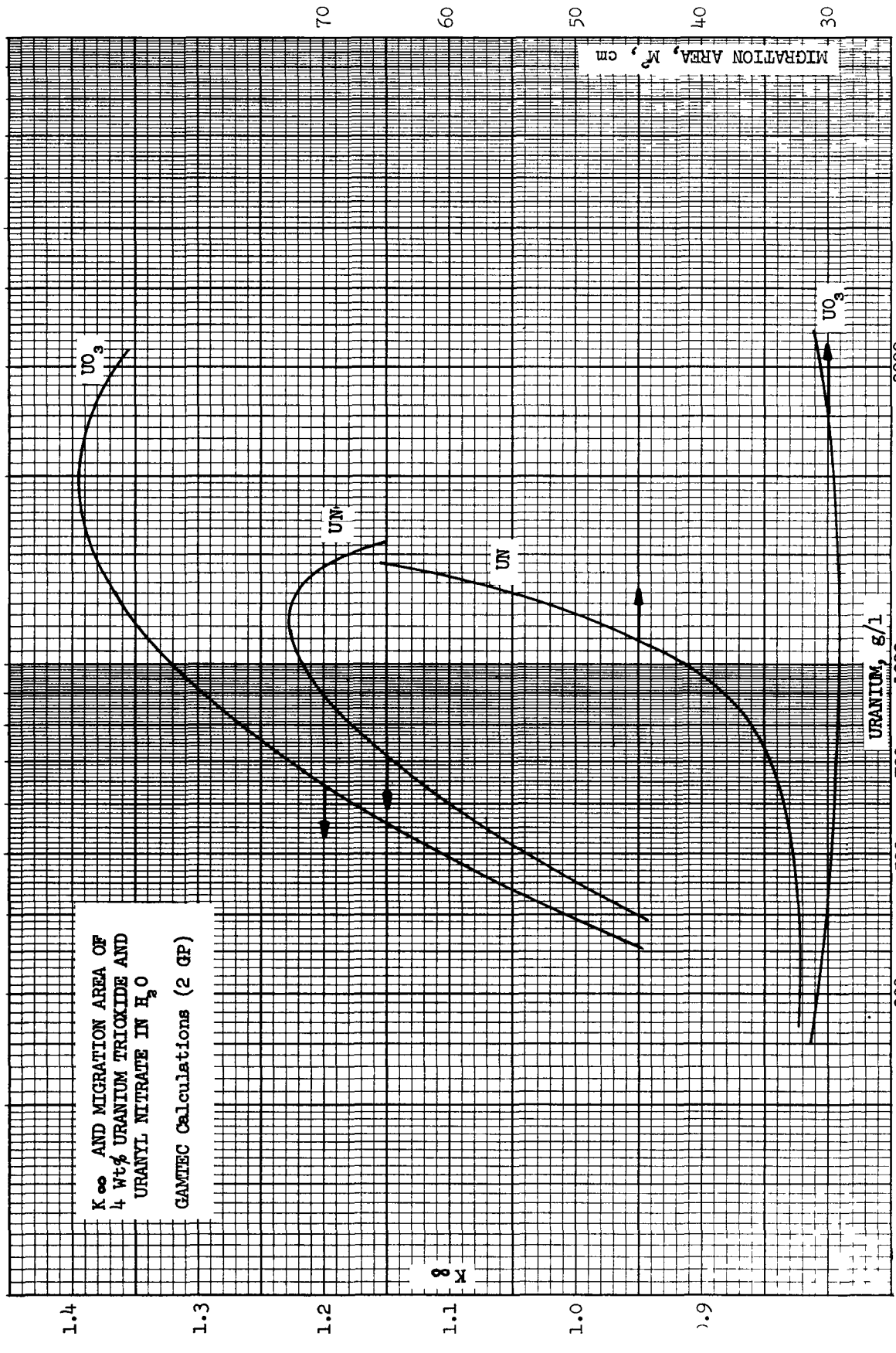

MIGRATION AREA, M², cm
50
40
30
5000
3000
1000
700
500
300
100
URANIUM, g/l
1.1
1.0
0.9
0.8
k∞
k∞ AND MIGRATION AREA FOR 1.25 WT% URANIUM TRIOXIDE IN H₂O
GAMTEC 2GP Calculations

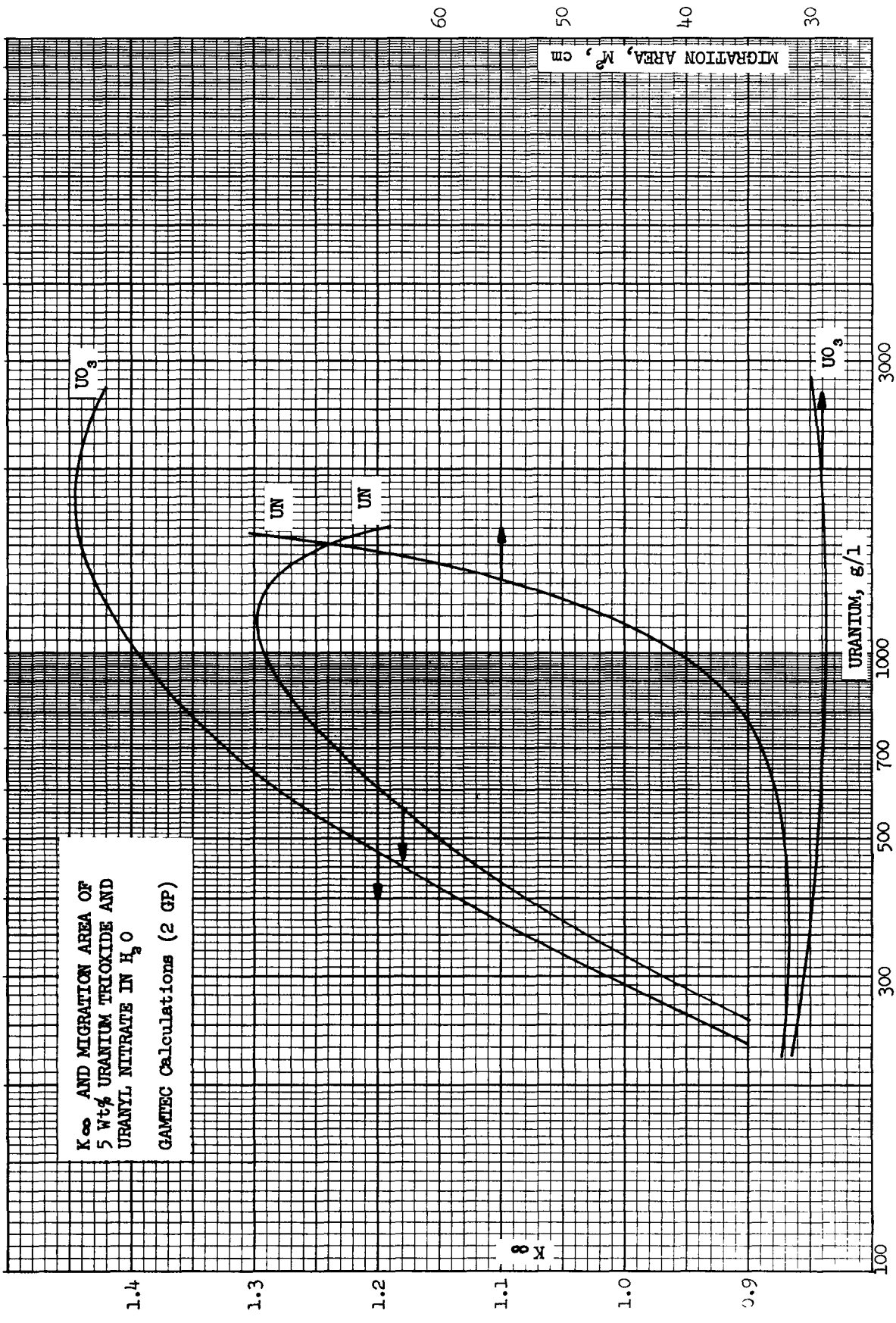

MIGRATION AREA, M², cm
40
30
20
3000
1000
700
500
300
100
K∞
1.1
1.0
0.9
0.8
K∞ AND MIGRATION AREA FOR
1.5 Wt% URANIUM TRIOXIDE IN H2O
GAMTEC Calculations (2 GP)

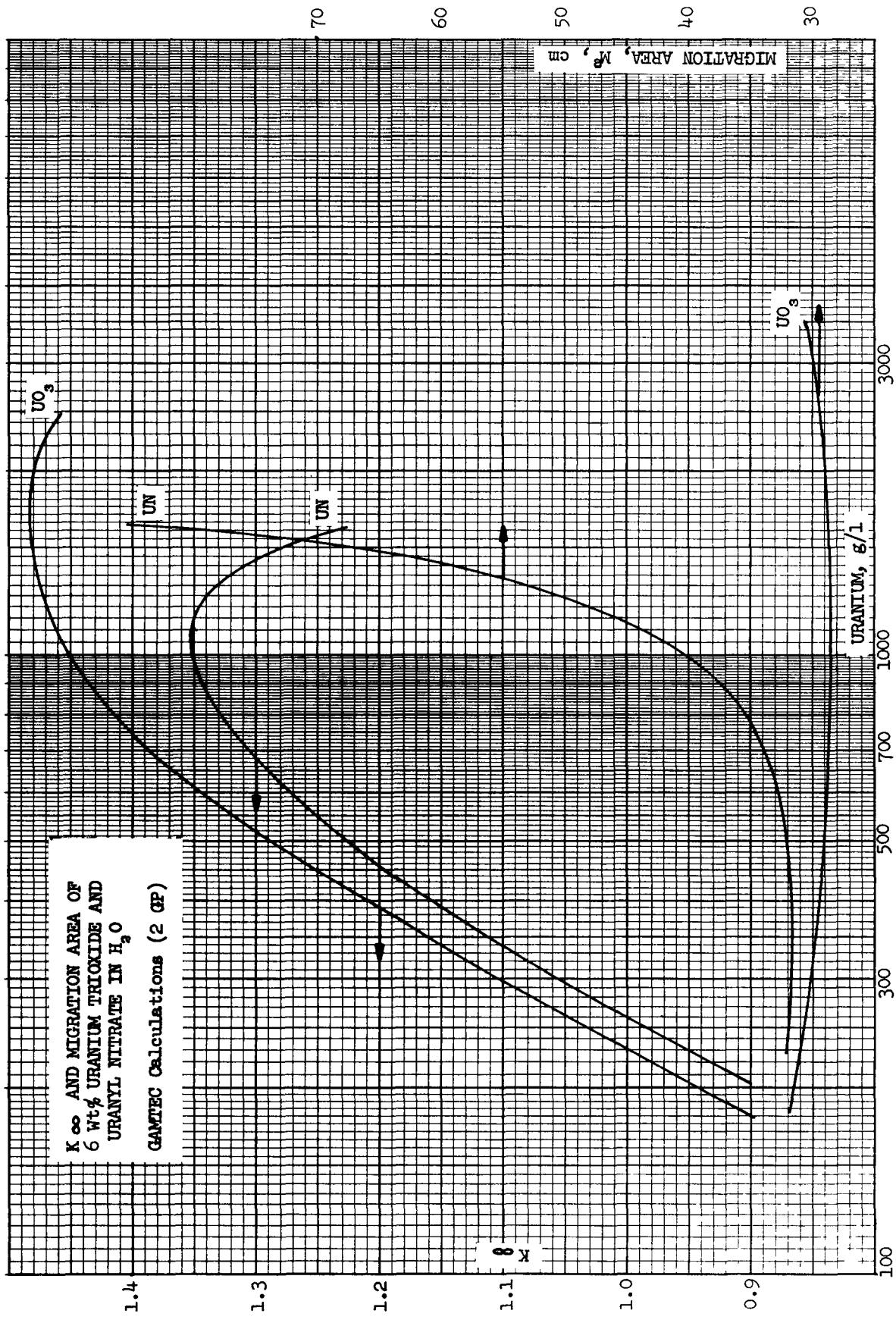

K∞ AND MIGRATION AREA FOR
2 wt% URANIUM TRIOXIDE AND
URANYL NITRATE AND 2.1 wt%
URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)
MIGRATION AREA, M, cm
60
50
40
30
UO_3
2.1 wt% UN
2.0 wt% UN
UN
UO_3
URANIUM, g/l
5000
3000
1000
700
500
300
100
K_∞
1.2
1.1
1.0
0.9
0.8

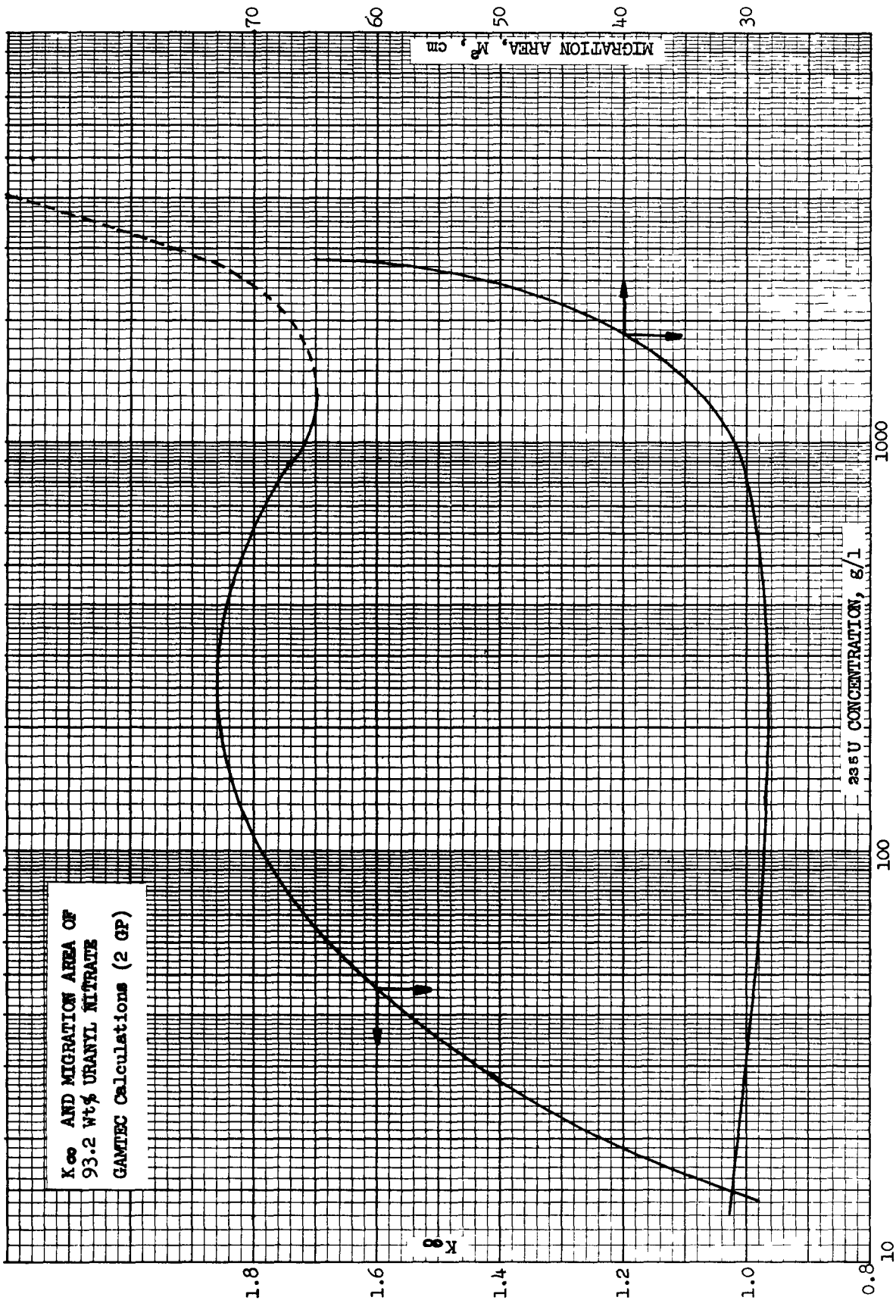

K∞ AND MIGRATION AREA FOR
2.5 Wt% URANIUM THIOXIDE
AND URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)
UO_3
UN
UN
UO_3
K∞
MIGRATION AREA, M^2, cm
URANIUM, g/l
1.2
1.1
1.0
0.9
0.8
60
50
40
30
20
100
300
500
700
1000
3000

K_∞ AND MIGRATION AREA FOR
3 Wt% URANIUM TRIOXIDE AND
URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)
K_∞
MIGRATION AREA, M^2, cm
URANIUM, g/l
UO_3
UN
UO_3
UN
1.3
1.2
1.1
1.0
0.9
60
50
40
30
100
300
500
700
1000
3000


K∞ AND MIGRATION AREA OF
4 Wt% URANIUM TRIOXIDE AND
URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)
K_∞
MIGRATION AREA, M^2, cm
URANIUM, g/l
UO_3
UN
UO_3
UN
1.4
1.3
1.2
1.1
1.0
.9
70
60
50
40
30
300
500
700
1000
3000


MIGRATION AREA, M^2, cm
60
50
40
30
UO_3
UN
UN
UO_3
URANIUM, g/l
3000
1000
700
500
300
100
K_∞
1.4
1.3
1.2
1.1
1.0
0.9
K_∞ AND MIGRATION AREA OF
5 Wt% URANIUM TRIOXIDE AND
URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)


K∞ AND MIGRATION AREA OF
6 wt% URANIUM TRIOXIDE AND
URANYL NITRATE IN H_2O
GAMTEC Calculations (2 GP)
UO_3
UN
UN
UO_3
K_∞
MIGRATION AREA, M^2, cm
URANIUM, g/l
1.4
1.3
1.2
1.1
1.0
0.9
70
60
50
40
30
100
300
500
700
1000
3000


K_∞ AND MIGRATION AREA OF
93.2 wt% URANYL NITRATE
GAMTEC Calculations (2 GP)
K_∞
MIGRATION AREA, M^2, cm
^{235}U CONCENTRATION, g/l
1.8
1.6
1.4
1.2
1.0
0.8
70
60
50
40
30
10
100
1000