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URANIUM-235 FISSION-PRODUCT PRODUCTION AS A FUNCTION OF THERMAL NEUTRON FLUX, IRRADIATION TIME, AND DECAY TIME. I. ATOMIC CONCENTRATIONS AND GROSS TOTALS

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CONTENTS

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ABSTRACT

Levels of fission products resulting from thermal fission of U^{235} in reactor fuels were computed over a wide range of reactor operating conditions and decay times. Values for approximately 300 fission products are presented in graphical form together with gross totals of their activities, radiation powers, and thermal neutron poisoning. The gamma spectrum is further broken into four groups of specified energy ranges, which are suitable for use in shielding design. Tabulations of these properties are arranged as to chain or mass number, element, and as to the rare-gas and rare-earth groups. The calculations assume constant replenishment of U^{235}, constant reactor power operation, and no fission-product separations during irradiation.

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1. INTRODUCTION

The production of fission products during reactor operation is an important consideration in almost every phase of atomic energy operations. While their presence must be considered in the design and operation of the reactor itself because of their contribution to neutron poisoning, they are of greatest importance in the chemical processing facilities. In these facilities the fission-product levels determine the shielding, off-gas treatment, and waste-disposal methods required for safe and successful operations, as well as the type of chemical process needed for their separation from the unused fissionable or fertile material in the fuel. It becomes mandatory, therefore, to have available extensive information on the chemical compositions and nuclear properties of the fission-product mixtures to be encountered.

The fission-product level in an irradiated reactor fuel is a function of three parameters: the operating power level of the reactor, the time of irradiation, and the decay time, or time elapsed since reactor shutdown. Estimates of fission-product levels normally are based either on calculations utilizing the fission yields, half lives, and genetic relations of the various species involved or on physical measurements of fission-product mixtures. Since about 300 nuclides – both radioactive and stable – are known or expected to exist after fission, calculations of fission-product mixtures can become quite laborious and in the most comprehensive cases are limited in accuracy by the uncertainties in the nuclear data. Experimental measurements of fission-product levels are normally limited in accuracy by the uncertainty in determining the number of fissions that have occurred in the experimental sample.

Fortunately, there are in the literature a large number of calculations and experimental determinations which frequently are of great aid in predicting those properties of fission-product mixtures which are of most interest. The curves of Borst and Wheeler (*1*), based on a series of cyclotron irradiations of uranyl nitrate salt, were among the first to be used for predictions of the total heat evolved. The mathematical relations of Way and Wigner (*2*), derived from a statistical consideration of the fission process, and the curves of Untermeyer and Weills (*3*), based on calorimetric measurements of irradiated uranium, are more recent studies of fission-product heat evolution. Very extensive calculations of the individual fission products have been performed by Faller, Chapman, and West (*4*); by Lock (*5*); and by Hunter and Ballou (*6*). Fission-product gamma decay levels, divided into seven energy groups suitable for shielding design, have been calculated by Moteff (*7*) and by Clark (*8*). The thermal neutron poisoning by fission products has been computed by Sampson *et al.* (*9*) and by Walker (*10*).

The present work represents an extension of the above calculations, both in detail and in the range of parameters considered. The calculations presented here, performed on the Oracle, an electronic digital computer at Oak Ridge National Laboratory (ORNL), were designed to give the information needed in the design of power reactor auxiliary systems over the widest ranges of parameters consistent with the accuracy of the nuclear data. Use of the Oracle has permitted calculations for virtually all known fission products, while at the same time taking into account the effect of neutron capture within the fission-product spectrum and the independent yields where known. In so far as possible, the most current and reliable nuclear data have been used to compute the number of atoms of each nuclide present, its activity, gamma power, total power, and thermal neutron poisoning. The gamma disintegrations have been classified into four groups of specified energy ranges. These properties have been totaled for each fission-product chain, for the isotopes of each element appearing as a fission product, for the rare gases, and for the rare earths. Finally, totals of these properties have been made over the entire fission-product spectrum.

The calculations assumed continuous replenishment of U^{235} during fission, constant reactor operating power, and no fission-product removal during irradiation. They were made for six values of thermal neutron flux ranging from 10^{12} to 10^{15} neutrons/cm^2/sec, for seven values of irradiation times from 10^5 to 10^8 sec, and for seven values of decay time from 10^3 to 10^9 sec.

The results are presented in two parts. Part I, this volume, contains curves expressing the atomic levels of the individual nuclides and the gross totals of the properties mentioned above. Also included in Part I are the nuclear data used in the calculations, a discussion of the calculations, and an explanation of how to interpret and use the curves.

Part II contains the results of the summations made on a "per chain" and a "per element" basis and for the rare-gas and rare-earth groups. These results appear in the form of tables from which graphs can be constructed for purposes of interpolation.

1.1 Nomenclature

The following nomenclature is used in this report.

N = number of atoms of any fission-product nuclide,

T = irradiation time, sec,

t = decay time, sec,

ϕ = thermal neutron flux, neutrons/cm^2/sec,

N_τ = number of atoms of any fission-product nuclide at irradiation time, τ,

N_t = number of atoms of any fission-product nuclide at decay time, t,

N_s = number of atoms of any fission-product nuclide at saturation,

N^0_{25} = number of atoms of U^{235} initially present,

N_s/N^0_{25} = number of atoms of any fission-product nuclide present at saturation, per initial atom U^{235},

N_τ/N_s = fraction of saturation of any fission-product nuclide at irradiation time, τ,

N_τ/N^0_{25} = number of atoms of any fission-product nuclide present at irradiation time, τ, per initial atom U^{235}; $N_\tau/N_s \times N_s/N^0_{25} = N_\tau/N^0_{25}$,

N_t/N_τ = fraction of shutdown value of any fission-product nuclide at decay time, t,

N_t/N^0_{25} = number of atoms of any fission-product nuclide present at decay time, t, per initial atom U^{235}; $N_t/N_\tau \times N_\tau/N_s \times N_s/N^0_{25} = N_t/N^0_{25}$,

Σ_f = macroscopic fission cross section of U^{235}, $580 \times 10^{-24}\ N^0_{25}$,

Σ = summation

σ_a = thermal neutron absorption cross section, barns,

λ = decay constant, (ln 2)/half life, sec^{-1},

Y = independent fission yield, per cent or ratio,

E = total energy of radiation, Mev,

E_g = total gamma energy, Mev,

E_b = total beta energy, Mev,

α, β = branching ratios,

Mw = megawatts,

Mwd = megawatt-days.

1.2 Acknowledgments

The writers would like to express their appreciation to all who have contributed their assistance and support in this problem. In particular, they would like to acknowledge the contributions of L. E. Glendenin and E. P. Steinberg, Argonne National Laboratory, for providing fission yields and for their review of Table 1. In addition, the assistance of the following personnel of ORNL is acknowledged: C. P. Hubbard, S. G. Campbell, and C. L. Gerberich for help with the Oracle code and operations; W. H Sullivan, H. S. Pomerance, and H. E. Williamson for assistance in gathering and checking the nuclear data; Mrs. Evelyn Bridges for her patience and perseverance in the preparation of the graphs; and H. E. Goeller for his many helpful suggestions relating to the format of the report. Finally, the writers feel that without the encouragement and support of R. A. Charpie, R. W. Stoughton, and J. Halperin, completion of the problem in its present form would have been impossible.

2. CALCULATIONS

The calculations are based on fitting each fission product chain to the generalized decay scheme proposed by Stoughton and Halperin (*11*) (Fig. 1). In this diagram the positions of the possible members of chain of mass number A are denoted by the numbers 6 through 11. The branching ratios are denoted by α and β; Y is the independent yield or the fraction of fissions resulting in the direct formation of the nuclide in question, and σ is the thermal-neutron absorption cross-section. Although not every decay chain fits this scheme perfectly, the few exceptions can be made to fit with the proper improvisations. Production by neutron capture is taken into account by consideration of the previous, or A-1, chain. To calculate the buildup of the A chain, there is a total of 11 possible nuclides for which expressions are needed, as follows:

(1) $$\frac{dN_1}{d\tau} = \Sigma_f \phi Y_1 - N_1\lambda_1 - N_1\sigma_1\phi ,$$

(2) $$\frac{dN_2}{d\tau} = \Sigma_f \phi Y_2 + N_1\lambda_1 - N_2\lambda_2 - N_2\sigma_2\phi ,$$

(3) $$\frac{dN_3}{d\tau} = \Sigma_f \phi Y_3 + N_2\lambda_2 - N_3\lambda_3 - N_3 (\sigma_3 + \sigma_{3'})\phi ,$$

(4) $$\frac{dN_4}{d\tau} = \Sigma_f \phi Y_4 + N_3\lambda_3 - N_4\lambda_4 - N_4\sigma_4\phi ,$$

(5) $$\frac{dN_5}{d\tau} = \Sigma_f \phi Y_5 + N_4\lambda_4 - N_5\sigma_5\phi ,$$

(6) $$\frac{dN_6}{d\tau} = \Sigma_f \phi Y_6 + N_1\sigma_1\phi - N_6\lambda_6 - N_6\sigma_6\phi ,$$

(7) $$\frac{dN_7}{d\tau} = \Sigma_f \phi Y_7 + N_2\sigma_2\phi + N_6\lambda_6 - N_7\lambda_7 - N_7\sigma_7\phi ,$$

(8) $$\frac{dN_8}{d\tau} = \Sigma_f \phi Y_8 + N_3\sigma_{3'}\phi + \alpha N_7\lambda_7 - N_8\lambda_8 - N_8\sigma_8\phi ,$$

(9) $$\frac{dN_9}{d\tau} = \Sigma_f \phi Y_9 + N_3\sigma_3\phi + (1 - \alpha)N_7\lambda_7 + (1 - \beta)N_8\lambda_8 - N_9\lambda_9 - N_9\sigma_9\phi ,$$

(10) $$\frac{dN_{10}}{d\tau} = \Sigma_f \phi Y_{10} + N_4\sigma_4\phi + \beta N_8\lambda_8 + N_9\lambda_9 - N_{10}\lambda_{10} - N_{10}\sigma_{10}\phi ,$$

(11) $$\frac{dN_{11}}{d\tau} = \Sigma_f \phi Y_{11} + N_5\sigma_5\phi + N_{10}\lambda_{10} - N_{11}\sigma_{11}\phi .$$

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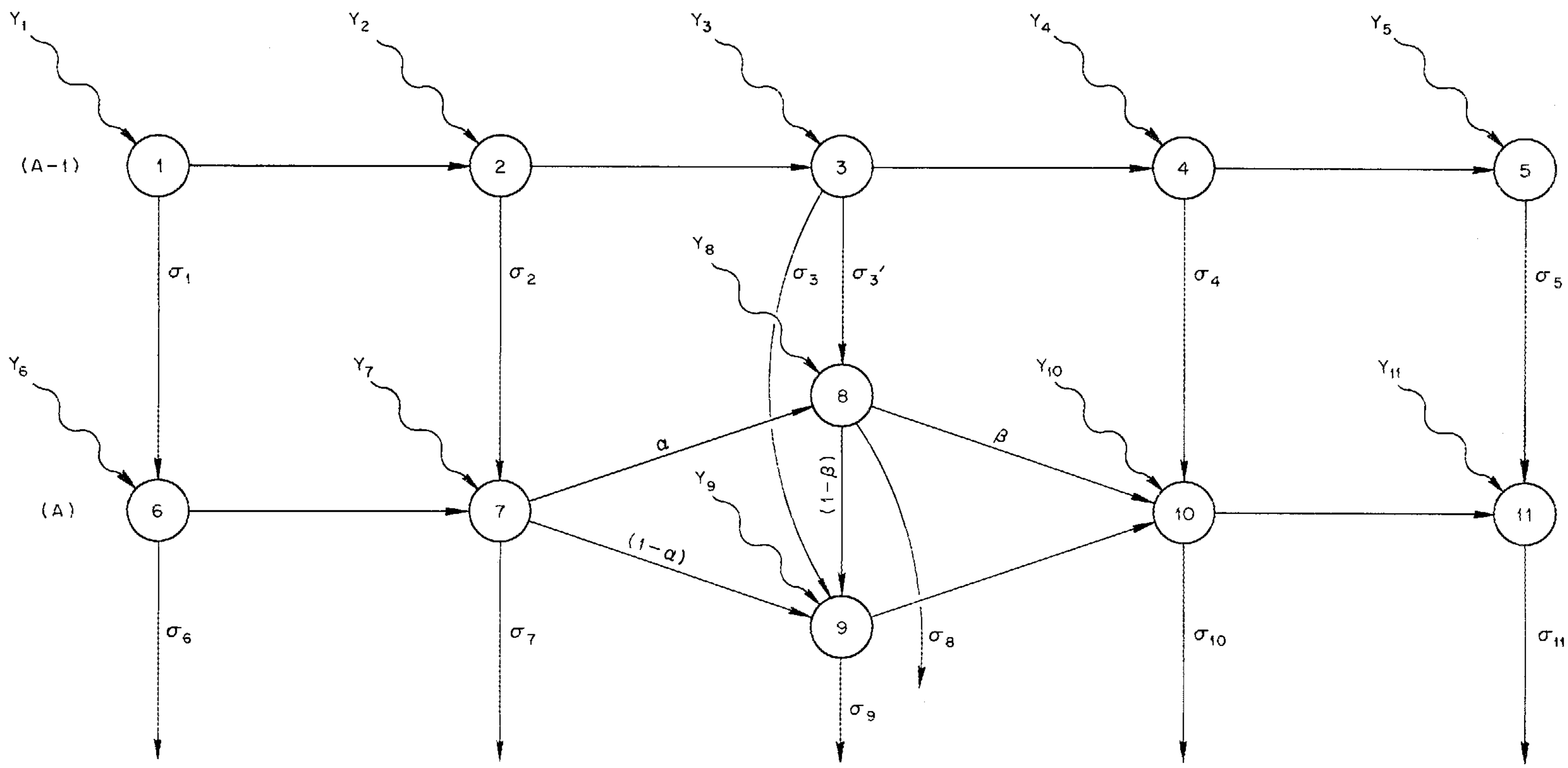

Fig. 1. Generalized Fission-Product Decay Scheme.

In the above equations the numerical subscripts refer to the respective nuclides as denoted in Fig. 1. The value N represents the number of atoms present at irradiation time, τ, and $dN/d\tau$ is the differential change in N with respect to time. Furthermore, Σ_f represents the macroscopic fission cross section, or the product of the number of atoms of U^{235} present and the microscopic fission cross section; Y, the independent fission yield; ϕ, the thermal neutron flux; λ, the decay constant, (ln 2)/half life; σ, the thermal-neutron capture cross section; and α and β, the branching ratios.

Equations 1 through 11 were solved analytically, considering Σ_f and ϕ as constants, to give N_1 through N_{11} as functions of τ. The significance of maintaining Σ_f constant is that, in so doing, the number of atoms of U^{235} initially present, N_{25}^0, is assumed to remain constant by virtue of replenishment of the atoms at a rate equal to that at which they are being consumed. In these calculations, N_{25}^0 was taken as unity, and the fission cross section of U^{235} was assumed as 580 barns.

To obtain solutions of N as functions of decay time, t, those terms containing ϕ in Eqs. 6 through 11 were dropped, and the resulting expressions were solved analytically for N_6 through N_{11}.

The two groups of solutions were coded for Oracle operations, and, by using the nuclear data given in Tables 1, 2, and 3, numerical values of N for every isotope were computed for the following values of parameters:

Thermal Neutron Flux, ϕ (neutrons/cm^2/sec)	Irradiation Time, τ (sec)	Cooling Time, t (sec)
10^{12}	10^5	10^3
10^{13}	3×10^5	10^4
3×10^{13}	10^6	10^5
10^{14}	3×10^6	10^6
3×10^{14}	10^7	10^7
10^{15}	3×10^7	10^8
	10^8	10^9

From the values of N so calculated, the various functions of N (including activity, power, and poisoning) were computed, stored on magnetic tape, and eventually summed in the several groups desired.

3. NUCLEAR DATA

A compilation of the nuclear properties of U^{235} fission products made primarily for use in these calculations has been published previously (*12*). The data were current in January 1954 and represented an accumulation of what was believed to be the best single values available at that time. The data of Tables 1, 2, and 2*a* (Table 3 in this report) are republished in this report with those changes made prior to starting the calculations.

Since nuclear data are very well organized and abstracted in the literature, the information was collected from a relatively few major sources. The decay chains were taken chiefly from Coryell and Sugarman (*13*); half-life values and decay schemes were taken from Hollander, Perlman, and Seaborg (*14*) and from the nuclear data collection of W. H Sullivan of ORNL. Thermal-neutron capture cross sections were taken from the compilation of Hughes and Harvey (*15*), and the majority of fission yields were values recommended by Glendenin and Steinberg (*16*).

In Table 1, the fission-product decay chains from mass number 72 through mass number 161 are given. Besides containing all nuclides for which evidence of formation in fission exists, this table includes certain products which could be formed indirectly as a result of n-γ reactions. Cumulative yields are given directly below each radioactive nuclide, and independent yields of stable and shielded nuclides are denoted by a superscript a. Yield values not in parentheses are those values recommended by Glendenin and Steinberg. These values were selected for their internal consistency as well as absolute accuracy and are given only to as many significant figures as their accuracy and consistency warrant. The yield values enclosed in parentheses were calculated by the equal charge displacement method of Glendenin, Coryell, and Edwards (*17*). The calculated values were used in cases where the cumulative yields could be expected to be less than about 99% of the chain yield. Where no yields are given for radioactive nuclides, it should be understood that these are products of neutron capture from the preceding chain.

A summary of nuclear properties, arranged in increasing order of atomic number and mass of the nuclides, is presented in Table 2. In addition to the cumulative and chain yields, independent yields are given where known. The average beta energies were computed as one-third the maximum beta energies. Again, those yields calculated by the method of equal charge displacement are enclosed in parentheses. While experimental values of the decay energies were always used in this table when available, there were many instances where none have been reported, and in such cases the energies were estimated either by use of the Q values or on the basis of mass difference. For shielding considerations, the gamma transitions were classified in four groups, depending on the energy of the transitions: group I, 0 to 0.25 Mev; group II, 0.26 to 1.00 Mev; group III, 1.01 to 1.70 Mev; group IV, 1.71 Mev and higher.

Table 3 is a separate listing of nuclides which may be expected to be present only as products of neutron capture from the preceding chain. This table is not complete, in that only those nuclides are included which can be calculated from known values of thermal-neutron absorption cross sections.

In the tables the symbol a denotes an independent fission yield; b shows that it is an energy value computed, by means of the Table of Atomic Masses (*18*), from the mass change; c denotes a nuclide which decays in part by K electron capture or positron emission; and d denotes an energy computed from the total disintegration energy or Q value.

4. RESULTS

The results given in Part I of this report are the N values for the individual fission-product nuclides and the grand totals of those functions of N which were computed. The results, all in graphical form, are presented in five groups (A, B, C, D, and T, in Appendix E) and are preceded by Table 5 (in Appendix A), which serves as an index to the figures. To facilitate and condense the presentation, the N values for the radioactive nuclides have been normalized as described below.

In Table 5, each isotope for which results are presented is listed under its chain, or mass number. Those isotopes which appear solely as the products of neutron capture are denoted both in the table and in the figures by an asterisk. Comparison of Table 5 with Tables 1, 2, and 3 indicates that a number of nuclides known or expected to be present in fission have not been considered in the present calculations. These omissions were made for reasons of necessity or convenience and in all cases were of minor or negligible importance.

Group A: The curves of Figs. A-1 through A-4*d* give the saturation values of each radioactive isotope as a function of thermal neutron flux. These values were obtained by setting the left side of Eqs. 6 through 10 equal to zero and solving for the respective N's for different values of ϕ. In the nomenclature of this report, the saturation values are represented by N_s and are plotted as N_s/N^0_{25}, the number of atoms at saturation per initial atom of U^{235}. Most of the curves are straight-line functions within the limits of plotting accuracy, the exceptions being those isotopes possessing significantly large rates of production or destruction by neutron capture. These saturation values were used to normalize the N values during their buildup (irradiation time) in the reactor. Saturation values of stable isotopes were not computed, for there is no advantage to be gained from normalizing the buildup of the stable species.

Group B: Values of N_τ, the number of atoms of fission-product nuclides present as a function of irradiation time, are presented for the radioactive nuclides in Figs. B-1 through B-46*a*. By normalizing these numbers with the saturation values from the curves of group A, the buildup of an isotope can frequently be represented by a single curve, independent of flux, expressing the fraction of saturation of the isotope, N_τ/N_s, at various irradiation times. The product of this number and the saturation value of the isotope at the flux in question, N_s/N^0_{25}, yields the number of atoms present at irradiation time, τ, per initial atom U^{235}, N_τ/N^0_{25}.

Group C: The curves in Figs. C-1 through C-60*a* give N_t, the number of atoms of the individual radioactive nuclides present as a function of decay time, or time following reactor shutdown. These numbers have been normalized with values of N_τ at reactor shutdown and are presented as fraction-of-shutdown values, N_t/N_τ. Normalization in this way made it possible in many cases to represent the values for all fluxes and irradiation times by a single curve. The number of atoms present at decay time, t, per initial atom U^{235}, N_t/N^0_{25}, is found as the product of N_t/N_τ, N_τ/N_s, and N_s/N^0_{25}.

Group D: The buildup of the stable isotopes during irradiation is presented in the curves of Figs. D-1 through D-111. These numbers are not normalized and are presented directly as

N_τ/N^0_{25}. Values of the stable isotopes as a function of decay time are not presented primarily because of space limitations. In those cases where this information is desired, it can be obtained by difference, considering the levels of all previous chain members.

Group T: The curves of Figs. T-1 through T-56*a* present the gross totals of the various properties of the fission product spectrum as a function of ϕ, τ, and t.

Figures T-1 through T-7*a*: Total fission-product activity, expressed in curies per initial atom of U^{235}, $\dfrac{\sum N/N^0_{25}\lambda}{3.7 \times 10^{10}}$.

Figures T-8 through T-14*a*: Total fission-product gamma power, expressed in watts per initial atom of U^{235}, $1.602 \times 10^{-13} \sum E_g \lambda N/N^0_{25}$.

Figures T-15 through T-21*a*: Total fission-product power, expressed in watts per initial atom of U^{235}, $1.602 \times 10^{-13} \sum E \lambda N/N^0_{25}$.

Figures T-22 through T-28*a*: Total fission-product poisoning, expressed in barns per initial atom of U^{235}, $\sum \sigma_a N/N^0_{25}$.

Figures T-29 through T-35*a*: Total fission-product gamma disintegrations per second per initial atom of U^{235} of energy ≤ 0.25 Mev.

Figures T-36 through T-42*a*: Total fission-product gamma disintegrations per second in the energy range 0.26 to 1.00 Mev.

Figures T-43 through T-49*a*: Total fission-product gamma disintegrations per second in the energy range 1.01 to 1.70 Mev.

Figures T-50 through T-56*a*: Total fission-product gamma disintegrations per second with energy greater than 1.70 Mev.

4.1 Illustrative Example

As an illustration of the use of these graphs, the amount will be determined of each member of chain 95 present in 1 metric ton of natural uranium which has been irradiated for 1160 Mwd at a power level of $33\frac{1}{3}$ Mw, then allowed to decay for 120 days.

Since natural uranium contains approximately 0.72% U^{235}, 1 metric ton of natural uranium contains 7.2 kg of U^{235}. Therefore,

$$N^0_{25} = \frac{(7.2 \text{ kg})\ (1000 \text{ g/kg})\ (6.02 \times 10^{23} \text{ atoms/mole})}{235 \text{ g/mole}} = 1.84 \times 10^{25} \text{ atoms} \ ,$$

$$\phi = \frac{(\text{power level, Mw})\ (3.2 \times 10^{16} \text{ fissions/sec/Mw})}{(N^0_{25})\ (U^{235} \text{ thermal fission cross section, cm}^2)}$$

$$= \frac{(33.3)\ (3.2 \times 10^{16})}{(1.84 \times 10^{25})\ (580 \times 10^{-24})} = 10^{14} \text{ neutrons/cm}^2\text{/sec} \ ,$$

$$T = \frac{(1160 \text{ Mwd})(8.64 \times 10^4 \text{ sec/day})}{(33.3 \text{ Mw})} = 3 \times 10^6 \text{ sec},$$

$$t = 120 \text{ days} = 10^7 \text{ sec} \ .$$

From Table 5, the nuclides of chain 95 which have been calculated are: 10.5m Y, 63d Zr, 90h Nb^m, 35d Nb, and stable Mo. Opposite each of these entries is given the numbers of the appropriate figures to be used in finding the number of atoms of each of these nuclides present under the prescribed conditions. The results of the stepwise procedure required are given in Table 4.

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APPENDIX A

TABLES

TABLE 1. U^{235} FISSION PRODUCT DECAY CHAINS

Mass No.	Atomic No. 30	31	32	33	34	35	36
72	49.0h Zn 1.5×10^{-5} →	14.3h Ga 1.5×10^{-5} →	Stable Ge				
73	<2m Zn (9.8×10^{-5}) →	5.0h Ga 1×10^{-4} →	Stable Ge				
74			Stable Ge 3×10^{-4a}				
75			82m Ge 8×10^{-4} →	Stable As			
76			Stable Ge 2×10^{-3a}	26.6h As →	Stable Se		
77			52s Ge 5.4×10^{-3} → (38.8h As); ⇣ (12h Ge)		<2% ⇢ 17.5s Se $<2 \times 10^{-4}$ ↓ (Stable Se)		
			12h Ge 3.7×10^{-3} →	38.8h As 9.1×10^{-3} →	>98% → Stable Se		
78			86m Ge 0.018 →	91m As 0.02 →	Stable Se		
79				9m As 0.04 → (3.5m Se); ⇢ (6.5×10^{4}y Se)	3.5m Se 0.04 ↓ (6.5×10^{4}y Se)		
					6.5×10^{4}y Se 0.04 →	Stable Br	
80					Stable Se 0.08^{a}		

TABLE I. (continued)

Mass No.	Atomic No. 33	34	35	36	37	38
81	<10m As (0.125) →	56.5m Se 0.008 ↓ 17m Se 0.133 →	Stable Br			
82		Stable Se 0.25[a]	35.87h Br 3.8×10^{-5}[a] →	Stable Kr		
83		67s Se 0.30 (>90% → 2.4h Br; <10% ↓ 25m Se) 25m Se 0.21 →	2.4h Br 0.48 → 114m Kr; - - → Stable Kr	114m Kr 0.48 ↓ Stable Kr		
84		~2m Se 1.1 →	30m Br 1.1 →	Stable Kr		
85			3.00m Br 1.5 → 4.36h Kr; - - → 10.27y Kr	4.36h Kr 1.5 (80% → Stable Rb; 20% ↓ 10.27y Kr) 10.27y Kr 0.3 →	Stable Rb	
86				Stable Kr 2.1[a]	19.5d Rb 2.8×10^{-5}[a] →	Stable Sr

TABLE 1. (continued)

Mass No.	Atomic No. 35	36	37	38	39	40	41
86		Stable Kr ↑ *n* (from Instant Kr)					
87	55.6s Br → 2.7	[2%] Instant Kr [98%] 78m Kr → 2.7	6.2×10^{10}y Rb → 2.7	Stable Sr			
88	15.5s Br → (2.9)	2.77h Kr → 3.7 ↑ *n* (from Instant Kr)	17.8m Rb → 3.7	Stable Sr			
89	4.51s Br → Instant Kr 4.51s Br - - - →	3.18m Kr → (4.6)	15.4m Rb → 4.8	54d Sr → 4.8	Stable Y		
90		33s Kr → (5.2)	2.74m Rb → 5.9	28y Sr → 5.9	64.5hY → 5.9	Stable Zr	
91		9.8s Kr → (3.7)	1.67m Rb → ↓ (dashed) 14m Rb → (5.7)	9.7h Sr → 5.9	[40%] 51m Y 2.4 ↓ [60%] 58d Y → 5.9	Stable Zr	
92		3.0s Kr → 2.7	80s Rb → 5.5	2.7h Sr → 6.1	3.60h Y → 6.1	Stable Zr	

TABLE 1. (continued)

Mass No.	Atomic No. 36	37	38	39	40	41	42
93	2.0s Kr (1.3) →	Short Rb (4.4) →	7m Sr (6.4) →	10.0h Y 6.5 →	1.1×10^6y Zr 6.5 → (33%) / → (67%)	4.2Y Nb 2.1 (33%) ↓ Stable Nb (67%)	
94	1.4s Kr (0.6) →	Short Rb (2.9) →	2.0m Sr (5.8) →	16.5m Y 6.5 →	Stable Zr		
95	Short Kr (0.2) →	Short Rb (1.6) →	Short Sr (4.7) →	10.5m Y 6.4 →	63d Zr 6.4 → (1%) / → (99%)	90h Nb 0.06 (1%) ↓ 35d Nb 6.4 (99%) →	Stable Mo
96					Stable Zr 6.4^{a}	23.4h Nb 5.7×10^{-4a} →	Stable Mo
97	~1s Kr (~0) →	Short Rb (0.1) →	Short Sr (1.7) →	Short Y (4.8) →	17.0h Zr 6.2 →	60s Nb 6.2 ↓ 72.1m Nb 6.2 →	Stable Mo

TABLE 1. (continued)

Mass No.	Atomic No. 42	43	44	45	46
98	Stable Mo 5.9[a]				
99	67h Mo 6.1 → (~10%) 6.04h Tc → (~90%) 2.12 × 10^5y Tc	6.04h Tc ~0.6 ↓ 2.12 × 10^5y Tc 6.1 →	Stable Ru		
100	Stable Mo 6.5[a]	15.8s Tc →	Stable Ru		
101	14.6m Mo → 5.0	14.0m Tc → 5.0	Stable Ru		
102	12m Mo → 4.2	<25s Tc → 4.2	Stable Ru		
103			41d Ru 2.9 → (>95%) 54m Rh ⇢ (<5%) Stable Rh	54m Rh 2.9 ↓ Stable Rh	
104			Stable Ru 1.8[a]	4.4m Rh ↓ 42s Rh →	Stable Pd

TABLE 1. (continued)

Mass No.	42	43	44	45	46	47	48
105	~5m Mo (0.6) →	Short Tc (0.9) →	4.5h Ru 0.9 →	45s Rh 0.9 ↓ (dotted); 36.5h Rh 0.9 →	Stable Pd		
106			1.0y Ru 0.38 →	30s Rh 0.38 →	Stable Pd		
107		$<$1.5m Tc (0.16) →	4m Ru 0.2 →	26m Rh 0.2 →	7.5×10^6y Pd 0.2 → (dashed) 44.3s Ag; → Stable Ag	44.3s Ag ↓ Stable Ag	
108					Stable Pd 0.08[a]		
109				$<$1h Rh (0.028) →	13.6h Pd 0.028 →	39.2s Ag 0.028 ↓ (dotted) Stable Ag	
110					Stable Pd 0.02[a]	270d Ag 2×10^{-7}[a] (~97% → Stable Cd; ~3% ↓); 24.2s Ag $\sim 6 \times 10^{-9}$ → Stable Cd	Stable Cd

TABLE 1. (continued)

Mass No.	Atomic No. 46	47	48	49	50
111	22m Pd 0.018 →	7.6d Ag 0.018 →	Stable Cd		
112	21h Pd 0.011 →	3.2h Ag 0.011 →	Stable Cd		
113		5.3h Ag 0.01	5.1y Cd (dashed arrow from 5.3h Ag) → Stable In; Stable Cd	Stable In	
114		2m Ag 0.01 →	Stable Cd		
115		20m Ag (~0.01)	9%: 43d Cd 7.1×10^{-4}; 91%: 53h Cd 9.8×10^{-3}	4.50h In 9.8×10^{-3} (94% → 6×10^{14}y In); 6×10^{14}y In 9.9×10^{-3}	Stable Sn (6% from 4.50h In)
116			Stable Cd 0.01^{a}	54.2m In; 13s In	Stable Sn

TABLE 1. (continued)

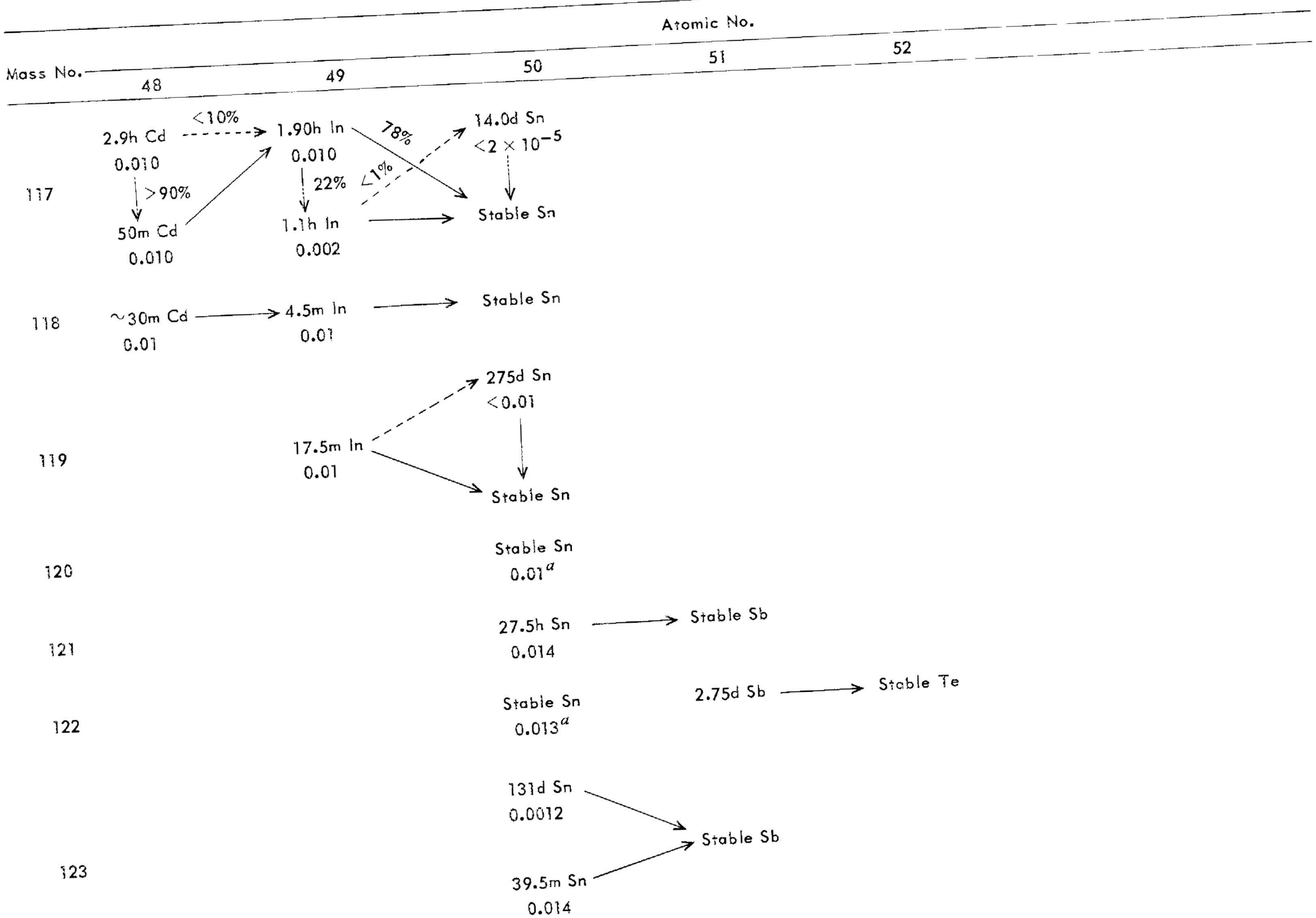

TABLE 1. (continued)

Mass No.	Atomic No. 50	51	52	53	54
124	Stable Sn 0.02[a]				
125	9.4d Sn 0.012 → ~2.7y Sb 9.5m Sn 0.011 → ~2.7y Sb	~2.7y Sb 0.023 14% → 58d Te 86% → Stable Te	58d Te 3×10^{-3} ↓ Stable Te		
126	50m Sn 0.1 →	9h Sb 0.1 →	Stable Te		
127	1.5h Sn (0.24) →	93h Sb 0.25 ~16% → 90d Te ~84% → 9.3h Te	90d Te 0.056 ↓ 9.3h Te 0.25 →	Stable I	
128		1.1h Sb 0.5 →	Stable Te	24.98m I →	Stable Xe
129		4.6h Sb 1.0 ~24% → 33d Te ~76% → 72m Te	33d Te 0.34 ↓ 72m Te 1.0 →	1.72×10^{7}y I 1.0 →	Stable Xe 4×10^{-4}[a]
130		12m Sb 2.0 →	$>10^{15}$y Te	12.6h I →	Stable Xe

TABLE 1. (continued)

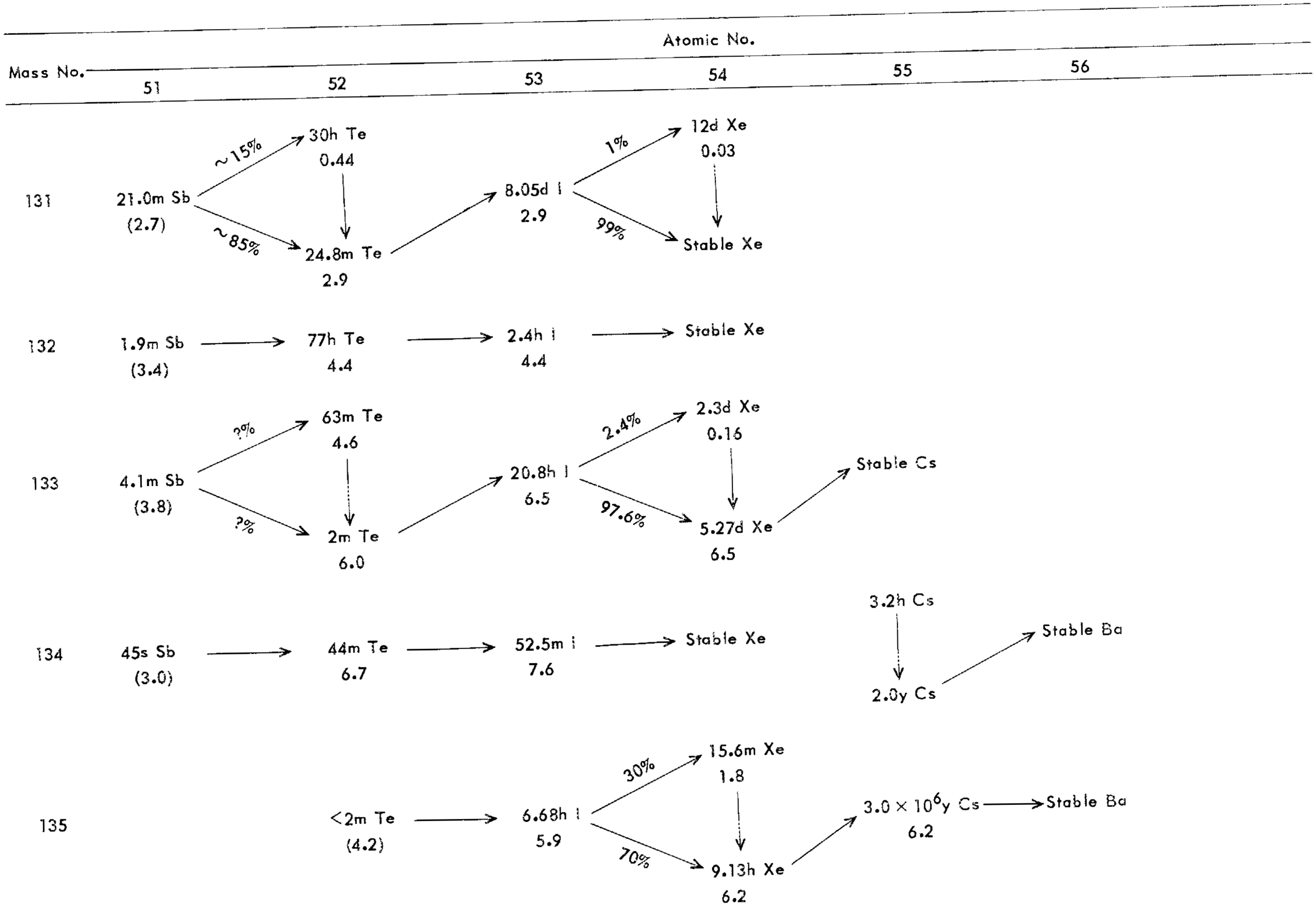

TABLE 1. (continued)

Mass No.	Atomic No. 53	54	55	56	57	58	59	60
136	86s I → 3.1	Stable Xe 3.2[a] ↑ n (from Instant Xe)	13d Cs → 0.0060[a]	Stable Ba				
137	22.0s I (4.9) ~6% → Instant Xe ~94% → 3.9m Xe	Instant Xe 3.9m Xe → (5.9)	26.6y Cs 5.9 92% → 2.60m Ba 8% → Stable Ba	2.60m Ba 5.4 ↓ Stable Ba				
138	5.9s I → (3.4)	17m Xe → (5.5)	32m Cs → 5.8	Stable Ba				
139	2.7s I → (1.8)	41s Xe → (4.7)	9.5m Cs → (5.9)	85m Ba → 6.0	Stable La			
140		16s Xe → (3.7)	66s Cs → (6.0)	12.80d Ba → 6.3	40.2h La → 6.3	Stable Ce		
141		1.7s Xe → (1.8)	Short Cs → (4.7)	18m Ba → 5.9	3.7h La → 6.0	32d Ce → 6.0	Stable Pr	
142			~1m Cs → (3.4)	6m Ba → (5.6)	74m La → 5.9	Stable Ce	19.3h Pr →	Stable Nd
143		1s Xe → (0.2)	Short Cs → (1.9)	<0.5m Ba → (4.9)	19m La → 6.2	32h Ce → 6.2	13.7d Pr → 6.2	Stable Nd
144		~1s Xe → (~0)	Short Cs → (1.0)	Short Ba → (3.5)	Short La → (5.8)	290d Ce → 6.1	17.5m Pr → 6.1	1.5×10^{15}y Nd

TABLE 1. (continued)

Mass No.	Atomic No. 58	59	60	61	62	63	64
145	3.0m Ce → 4.2	6.0h Pr → 4.2	Stable Nd				
146	13.9m Ce → (3.2)	24.4m Pr → 3.3	Stable Nd				
147			11.3d Nd → 2.6	2.6y Pm → 2.6	1.4×10^{11}y Sm		
148			Stable Nd 1.8[a]	5.3d Pm →	Stable Sm		
149			2.0h Nd → 1.3	54h Pm → 1.3	Stable Sm		
150			$>2 \times 10^{15}$y Nd 0.74[a]		Stable Sm		
151			15m Nd → (0.48)	27.5h Pm → 0.5	93y Sm → 0.5	Stable Eu	
152					Stable Sm 0.3[a]	9.2h Eu → 13y Eu →	Stable Gd
153					47h Sm → 0.15	Stable Eu	
154					Stable Sm 0.09[a]	16y Eu →	Stable Gd

TABLE 1. (concluded)

Mass No.	Atomic No. 62	63	64	65	66
155	23.5m Sm → 0.031	1.7y Eu → 0.031	Stable Gd		
156	~10h Sm → 0.013	15.4d Eu → 0.013	Stable Gd		
157		15.4h Eu → 7.4×10^{-3}	Stable Gd		
158		60m Eu → 2×10^{-3}	Stable Gd		
159			18.0h Gd → 1.1×10^{-3}	Stable Tb	
160			Stable Gd 3×10^{-4}[a]	73.5d Tb →	Stable Dy
161			3.6m Gd → 8.0×10^{-5}	7.0d Tb → 8.0×10^{-5}	Stable Dy

TABLE 2. NUCLEAR PROPERTIES OF U^{235} FISSION PRODUCTS

Arranged According to Increasing Order of Atomic Number and Mass

						Energy of Radiation								
						Beta Particles			Gamma Transitions					
											Shielding			
Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	E_b (Mev)	(%)	Av. E_b (Mev)	E_g (Mev)	(%)	Group	(%)	Total E_g (Mev)	Total E (Mev)
$_{30}Zn$	72	49h	3.93×10^{-6}	---	1.5×10^{-5}	0.3	~95	~0.122	---	---	II	~100	0.91^b	1.03
						1.6	~5							
	73	<2m	5.75×10^{-3}	---	(9.8×10^{-5})	4.9^b	100	1.6^b	---	~0	---	---	~0	1.6^b
$_{31}Ga$	72	14.3h	1.351×10^{-5}	---	1.5×10^{-5}	0.6	40	0.390	2.51	26	II	~126	2.70	3.09
						0.9	32		2.21	33	III	~12		
						1.5	11		1.87	8	IV	~67		
						2.52	8		1.59	5				
						3.15	9		1.20	<2				
									1.05	5				
									0.84	100				
									0.68	<2				
									0.63	24				
	73	5.0h	3.85×10^{-5}	---	1×10^{-4}	1.4	100	0.47	0.054	100	I	200	0.068	0.538
					$(2 \times 10^{-6})^a$				0.0135	100				
$_{32}Ge$	72	Stable	0	0.94	1.5×10^{-5}	0	0	0	0	0	---	---	0	0
	73	Stable	0	13.7	1×10^{-4}	0	0	0	0	0	---	---	0	0
	74	Stable	0	0.60	3×10^{-4a}	0	0	0	0	0	---	---	0	0
	75	82m	1.41×10^{-4}	---	8×10^{-4}	0.614	15	0.353	0.572	---	II	15	0.08^d	0.43
						1.137	85		0.418	---				
									0.265	---				
	76	Stable	0	0.015 + 0.30	2×10^{-3a}	0	0	0	0	0	---	---	0	0
	77*m*	52s	1.340×10^{-2}	---	5.4×10^{-3}	2.7	100	0.90	0.215	100	I	200	0.384	1.27
									0.159	---				
	77	12h	1.60×10^{-5}	---	3.7×10^{-3}	0.71	23	0.523	0.26	---	I	~100	0.89^d	1.41
						1.379	35		0.21	---	II	~100		
						2.196	42							
	78	86m	1.34×10^{-4}	---	1.8×10^{-2}	0.9	100	0.3	0	0	---	---	0	0.3
$_{33}As$	75	Stable	0	4.1	8×10^{-4}	0	0	0	0	0	---	---	0	0
	77	38.8h	4.96×10^{-6}	---	9.1×10^{-3}	0.700	~100	~0.233	0	0	---	---	0	0.233
	78	91m	1.27×10^{-4}	---	2×10^{-2}	1.4	30	1.10	0.27	---	II	~300	0.8^d	1.90
					2×10^{-3a}	4.1	70							
	79	9m	1.28×10^{-3}	---	4×10^{-2}	2.1	100	0.7	0	0	---	---	0	0.7
	81	<10m	1.16×10^{-3}	---	(0.125)	5.1^b	100	1.7^b	---	~0	---	---	~0	1.7^b
$_{34}Se$	77*m*	17.5s	3.96×10^{-2}	---	$<2 \times 10^{-4}$	0	0	0	0.162	100	I	100	0.162	0.162
	77	Stable	0	40	9.1×10^{-3}	0	0	0	0	0	---	---	0	0
	78	Stable	0	0.4	2×10^{-2}	0	0	0	0	0	---	---	0	0
	79*m*	3.9m	1.28×10^{-3}	---	4×10^{-2}	0	0	0	0.096	100	I	100	0.096	0.096
	79	6.5×10^4y	3.38×10^{-13}	---	4×10^{-2}	0.160	100	0.053	0	0	---	---	0	0.053
	80	Stable	0	0.03 + 0.5	8×10^{-2a}	0	0	0	0	0	---	---	0	0
	81*m*	56.5m	2.04×10^{-4}	---	8×10^{-3}	0	0	0	0.103	100	I	100	0.103	0.103

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles: E_b (Mev)	(%)	Av. E_b (Mev)	Gamma Transitions: E_g (Mev)	(%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{34}Se$	81	17m	6.80×10^{-4}	---	0.133	1.38	100	0.46	0	0	---	---	0	0.46
	82	Stable	0	2	0.25[a]	0	0	0	0	0	---	---	0	0
	83m	67s	1.03×10^{-2}	---	0.30	3.4	100	1.13	0	---	---	---	---	~1.13
	83	25m	4.62×10^{-4}	---	0.21	1.5	100	0.5	0.950	---	I	~200	~3.1[b]	~3.6
									0.176	---	II	~200		
									0.061					
									0.04					
	84	~2m	5.78×10^{-3}	---	1.1	2.94[b]	100	0.98[b]	---	~0	---	---	~0	0.98[b]
$_{35}Br$	79	Stable	0	2.6 + 7.6	3.7×10^{-2}	0	0	0	0	0	---	---	0	0
	81	Stable	0	2.6	0.133	0	0	0	0	0	---	---	0	0
	82	35.87h	5.37×10^{-6}	---	3.8×10^{-5}[a]	0.465	100	0.155	1.312	---	II	~100	3.6[b]	~3.8
									1.031	---	III	~200		
									0.823	---				
									0.766	---				
									0.692	---				
									0.608	---				
									0.547	---				
	83	2.4h	8.02×10^{-5}	---	0.48	0.940	100	0.313	0.051	100	I	100	0.051	0.364
	84	30m	3.85×10^{-4}	---	1.1	1.72	35	1.065	1.89	---	II	~150	2.4[b]	3.5
						2.53	16		0.89	---	IV	~50		
						3.56	9							
						4.68	40							
	85	3.0m	3.85×10^{-3}	---	1.5	2.5	100	0.83	0	0	---	---	0	0.83
	87	55.6s	1.25×10^{-2}	---	2.7	2.6	70	1.41	5.4	56	IV	70	~3.78[d]	~5.19
						8.0	30		~3	14				
	88	15.5s	4.47×10^{-2}	---	(2.9)	8.70[b]	100	2.90[b]	---	~0	---	---	~0	2.90[b]
	89	4.51s	1.54×10^{-2}	---	?	7.10[b]	100	2.37[b]	---	~0	---	---	~0	2.37[b]
$_{36}Kr$	82	Stable	0	45	3.5×10^{-5}	0	0	0	0	0	---	---	0	0
	83m	114m	1.01×10^{-4}	---	0.48	0	0	0	0.0322	100	I	200	0.0415	0.0415
									0.0093	100				
	83	Stable	0	205	0.48	0	0	0	0	0	---	---	0	0
	84	Stable	0	1.0 + 0.06	1.1	0	0	0	0	0	---	---	0	0
	85m	4.36h	4.41×10^{-5}	0.096	1.5	0.835	80	0.233	0.305	20	I	80	0.181	0.414
									0.1495	80	II	20		
	85	10.27y	2.14×10^{-9}	<15	0.3	0.695	99+	~0.232	0	~0	---	---	~0	0.232
	86	Stable	0	0.06	2.1[a]	0	0	0	0	0	---	---	0	0
	87	78m	1.48×10^{-4}	<470	2.7	1.27	25	1.01	2.3	<25	II	~20	0.56[d]	1.57
						3.63	75		1.89	<25	IV	~25		
									0.41	<25				
	88	2.77h	6.95×10^{-5}	---	3.7	0.52	70	0.331	2.40	35	I	49	2.07	2.40
					(0.8)[a]	0.9	10		2.19	18	II	28		
						2.7	20		1.85	15	III	18		
									1.55	14	IV	68		
									1.20	4				
									0.85	23				
									0.365	5				
									0.191	35				
									0.163	7				
									0.028	7				

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Gamma Transitions Shielding Group	Gamma Transitions Shielding (%)	Gamma Transitions Total E_g (Mev)	Total E (Mev)
$_{36}Kr$	89	3.18m	3.63×10^{-3}	---	(4.6)	4.0	100	1.3	0	0	---	---	0	1.3
	90	~33s	2.10×10^{-2}	---	(5.2)	3.2	100	1.07	0	0	---	---	0	1.07
	91	9.8s	7.08×10^{-2}	---	(3.7)	3.6	100	1.20	0	0	---	---	0	1.20
	92	3.0s	0.231	---	(2.7)	5.0^b	100	1.67^b	---	~0	---	---	~0	1.67^b
	93	2.0s	0.347	---	(1.3)	8.0^b	100	2.66^b	---	~0	---	---	~0	2.66^b
	94	1.4s	0.495	---	(0.6)	6.4^b	100	2.14^b	---	~0	---	---	~0	2.14^b
	95	Short	---	---	(0.2)	9.3^b	100	3.1^b	---	~0	---	---	~0	3.1^b
	97	~1s	0.693	---	(~0)	10.6^b	100	3.5^b	---	~0	---	---	~0	3.5^b
$_{37}Rb$	85	Stable	0	0.05 + 0.85	1.5	0	0	0	0	0	---	---	0	0
	86	19.5d	4.11×10^{-7}	---	2.8×10^{-5a}	0.68	12	0.543	1.076	12	III	12	0.130	0.673
						1.76	88							
	87	6.2×10^{10}y	3.54×10^{-19}	0.14	2.7	0.275	100	0.092	0	0	---	---	0	0.092
	88	17.8m	6.49×10^{-4}	<200	3.7	2.5	9	1.61	2.8	---	II	5	0.47^d	2.08
						3.6	13		1.86	---	IV	22		
						5.3	78		0.9	---				
	89	15.4m	7.50×10^{-4}	---	4.8	4.5	100	1.5	0	0	---	---	0	1.5
					$(0.2)^a$									
	90	2.74m	4.22×10^{-3}	---	5.9	5.7	100	1.9	0	0	---	---	0	1.9
					$(0.7)^a$									
	91m	1.67m	6.93×10^{-3}	---	?	4.6	100	1.5	?	?	---	---	?	~1.5
	91	14m	8.25×10^{-4}	---	(5.7)	3.0	100	1.0	?	?	---	---	?	~1.0
					$(2.0)^a$									
	92	80s	8.66×10^{-3}	---	(5.5)	7.59^b	100	2.5^b	---	~0	---	---	~0	2.5^b
					$(2.8)^a$									
	93	Short	---	---	(4.4)	6.04^b	100	2.0^b	---	~0	---	---	~0	2.0^b
					$(3.1)^a$									
	94	Short	---	---	(2.9)	8.97^b	100	3.0^b	---	~0	---	---	~0	3.0^b
					$(2.3)^a$									
	95	Short	---	---	(1.6)	7.43^b	100	2.5^b	---	~0	---	---	~0	2.5^b
					$(1.4)^a$									
	97	Short	---	---	(0.1)	8.75^b	100	2.9^b	---	~0	---	---	~0	2.9^b
$_{38}Sr$	86	Stable	0	1.3 + ?	2.8×10^{-5}	0	0	0	0	0	---	---	0	0
	87	Stable	0	---	2.7	0	0	0	0	0	---	---	0	0
	88	Stable	0	0.005	3.7	0	0	0	0	0	---	---	0	0
	89	54d	1.48×10^{-7}	<130	4.8	1.463	100	0.487	0	0	---	---	0	0.487
	90	28y	7.85×10^{-10}	~1	5.9	0.61	100	0.20	0	0	---	---	0	0.20
	91	9.7h	1.99×10^{-5}	---	5.9	0.62	7	0.533	1.413	7	II	62	0.845	1.38
					$(0.2)^a$	1.09	33		1.025	33	III	40		
						1.36	29		0.747	7				
						2.03	4		0.66	22				
						2.665	27		0.64	33				

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Gamma Transitions Shielding Group	Gamma Transitions Shielding (%)	Gamma Transitions Total E_g (Mev)	Total E (Mev)
$_{38}Sr$	92	2.7h	7.13×10^{-5}	---	6.1	1.14[b]	100	0.4[b]	---	~0	---	---	~0	0.4[b]
					(0.6)[a]									
	93	7m	1.65×10^{-3}	---	(6.4)	4.13[b]	100	1.4[b]	---	~0	---	---	~0	1.4[b]
					(2.0)[a]									
	94	2.0m	5.78×10^{-3}	---	(5.8)	2.63[b]	100	0.9[b]	---	~0	---	---	~0	0.9[b]
					(2.9)[a]									
	95	Short	---	---	(4.7)	5.55[b]	100	1.8[b]	---	~0	---	---	~0	1.8[b]
					(3.1)[a]									
	97	Short	---	---	(1.7)	6.90[b]	100	2.3[b]	---	~0	---	---	~0	2.3[b]
					(1.6)[a]									
$_{39}Y$	89	Stable	0	1.4	4.8	0	0	0	0	0	---	---	0	0
	90	64.5h	2.98×10^{-6}	<6.5	5.9	2.18[d]	100	0.73	1.4	0.4	III	0.4	~0	~0.73
	91*m*	51m	2.26×10^{-4}	---	2.4	0	0	0	0.551	100	II	100	0.551	0.551
	91	58d	1.38×10^{-7}	---	5.9	1.537	~100	0.512	1.22	0.3	III	0.3	~0	~0.512
	92	3.60h	5.35×10^{-5}	---	6.1	1.3	---	~1.2[b]	0.6	---	II	---	~0	~1.2[b]
						2.7	---							
						3.6	---							
	93	10.0h	1.93×10^{-5}	---	6.5	3.1	100	1.03	0.7	100	II	100	0.7	1.73
					(0.1)[a]									
	94	16.5m	7.00×10^{-4}	---	6.5	5.4	100	1.8	1.4	100	III	100	1.4	3.2
					(0.7)[a]									
	95	10.5m	1.10×10^{-3}	---	(6.4)	3.66[b]	100	1.2	0	0	---	---	0	1.2
					(1.7)[a]									
	97	Short	---	---	(4.8)	5.06[b]	100	1.7[b]	---	~0	---	---	~0	1.7[b]
					(3.1)[a]									
$_{40}Zr$	90	Stable	0	0.1	5.9	0	0	0	0	0	---	---	0	0
	91	Stable	0	1.5	5.9	0	0	0	0	0	---	---	0	0
	92	Stable	0	0.2	6.1	0	0	0	0	0	---	---	0	0
	93	1.1×10^6y	2.31×10^{-14}	<4	6.5	0.063	100	0.021	0	0	---	---	0	0.021
	94	Stable	0	0.07	6.5	0	0	0	0	0	---	---	0	0
	95	63d	1.27×10^{-7}	---	6.4	0.364	57	0.127	0.717	98	II	99	0.733	0.860
						0.396	42							
						0.883	1							
	96	Stable	0	0.05	6.4[a]	0	0	0	0	0	---	---	0	0
	97	17.0h	1.13×10^{-5}	---	6.2	1.91	100	0.64	---	---	II	100	0.75[d]	1.39[d]
					(1.4)[a]									
$_{41}Nb$	93*m*	4.2y	5.24×10^{-9}	---	2.1	0	0	0	0.0292	100	I	100	0.0292	0.0292
	93	Stable	0	1.1	6.5	0	0	0	0	0	---	---	0	0
	95*m*	90h	2.14×10^{-6}	---	0.06	0	0	0	0.235	100	I	100	0.235	0.235
	95	35d	2.29×10^{-7}	---	6.4	0.160	100	0.053	0.745	100	II	100	0.745	0.798

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{41}$Nb	96	23.4h	8.23×10^{-6}	---	5.7×10^{-4}[a]	0.37	8	0.240	1.187	32	I	17	2.40	2.64
						0.750	92		1.078	52	II	210		
									0.840	16	III	84		
									0.804	6				
									0.770	100				
									0.560	61				
									0.451	27				
									0.238	10				
									0.216	7				
	97*m*	60s	1.16×10^{-2}	---	6.2	0	0	0	0.747	100	II	100	0.747	0.747
	97	72.1m	1.60×10^{-4}	---	6.2	1.267	100	0.422	0.665	100	II	100	0.665	1.087
$_{42}$Mo	95	Stable	0	13.4	6.4	0	0	0	0	0	---	---	0	0
	96	Stable	0	1	5.7×10^{-4}	0	0	0	0	0	---	---	0	0
	97	Stable	0	2	6.2	0	0	0	0	0	---	---	0	0
	98	Stable	0	0.13	5.9[a]	0	0	0	0	0	---	---	0	0
	99	67h	2.88×10^{-6}	---	6.1	0.45	~13	0.376	0.780	---	I	90	0.24[d]	0.616[d]
						1.23	~87		0.740	---	II	10		
									0.181	---				
									0.140	---				
									0.041	---				
	100	Stable	0	0.2	6.5[a]	0	0	0	0	0	---	---	0	0
	101	14.6m	7.91×10^{-4}	---	5.0	1.2	70	0.5	0.960	70	I	100	0.864	1.36
						2.2	30		0.191	100	II	70	---	
	102	12m	9.63×10^{-4}	---	4.2	0.92[b]	100	0.31[b]	---	~0	---	---	~0	0.31[b]
	105	~5m	2.31×10^{-3}	---	(0.6)	4.94[b]	100	1.65[b]	---	~0	---	---	~0	1.65[b]
$_{43}$Tc	99*m*	6.04h	3.19×10^{-5}	---	~0.6	0	0	0	0.141	100	I	100	0.141	0.141
	99	2.12×10^{5}y	1.04×10^{-13}	19	6.1	0.290	100	0.097	0	0	---	---	0	0.097
	101	14.0m	8.25×10^{-4}	---	5.0	1.20	100	0.40	0.30	100	II	100	0.30	0.70
	102	<25s	2.77×10^{-2}	---	4.2	3.31[b]	100	1.10[b]	---	~0	---	---	~0	1.1[b]
	105	Short	---	---	(0.9)	3.24[b]	100	1.08[b]	---	~0	---	---	~0	1.1[b]
				---	(0.3)[a]									
	107	<1.5m	7.7×10^{-3}	---	(0.16)	4.5[b]	100	1.5[b]	---	~0	---	---	~0	1.5[b]
$_{44}$Ru	99	Stable	0	---	6.1	0	0	0	0	0	---	---	0	0
	101	Stable	0	2.46	5.0	0	0	0	0	0	---	---	0	0
	102	Stable	0	1.2	4.2	0	0	0	0	0	---	---	0	0
	103	41d	1.96×10^{-7}	---	2.9	0.217	95	0.080	0.498	95	II	95	0.473	0.567
						0.698	5							
	104	Stable	0	0.7	1.8[a]	0	0	0	0	0	---	---	0	0
	105	4.5h	4.28×10^{-5}	---	0.9	1.150	100	0.383	0.726	100	II	100	0.726	1.109
	106	1.0y	2.20×10^{-8}	---	0.38	0.0392	100	0.0131	0	0	---	---	0	0.0131
	107	4m	2.89×10^{-3}	---	0.2	2.81[b]	100	0.94[b]	---	~0	---	---	~0	0.94[b]
					(0.04)[a]									

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Beta Particles: E_b (Mev)	Beta Particles: (%)	Beta Particles: Av. E_b (Mev)	Gamma Transitions: E_g (Mev)	Gamma Transitions: (%)	Shielding: Group	Shielding: (%)	Total E_g (Mev)	Total E (Mev)
$_{45}Rh$	103*m*	54m	2.14×10^{-4}	---	2.9	0	0	0	0.040	100	I	100	0.04	0.04
	103	Stable	0	12 + 138	2.9	0	0	0	0	0	---	---	0	0
	105*m*	45s	1.54×10^{-2}	---	0.9	0	0	0	0.130	100	I	100	0.130	0.130
	105	36.5h	5.27×10^{-6}	---	0.9	0.25	10	0.183	0.322	10	II	10	0.032	0.215
						0.570	90							
	106	30s	2.31×10^{-2}	---	0.38	~1.0	6	1.05	2.41	0.25	II	38	0.245	1.30
						2.0	3		1.55	0.5	III	2.5		
						2.44	12		1.045	2	IV	1		
						3.1	11		0.87	1				
						3.53	68		0.624	12				
									0.513	25				
	107	26m	4.44×10^{-4}	---	0.2	1.2	100	0.4	0	0	---	---	0	0.4
	109	<1h	1.93×10^{-4}	---	(0.028)	2.39[b]	100	0.8[b]	---	~0	---	---	~0	0.8[b]
$_{46}Pd$	105	Stable	0	---	0.9	0	0	0	0	0	---	---	0	0
	106	Stable	0	---	0.38	0	0	0	0	0	---	---	0	0
	107	7.5×10^6y	2.92×10^{-15}	---	0.2	0.04	100	0.01	0	0	---	---	0	0.01
	108	Stable	0	0.07 + 11	0.08[a]	0	0	0	0	0	---	---	0	0
	109	13.6h	1.42×10^{-5}	---	0.028	0.961	100	0.32	0	0	---	---	0	0.32
	110	Stable	0	? + 0.4	0.02[a]	0	0	0	0	0	---	---	0	0
	111	22m	5.25×10^{-4}	---	0.018	2.13	100	0.71	0.73	---	II	~0	~0[b]	0.71
									0.65	---				
									0.56	---				
									0.38	---				
	112	21h	9.17×10^{-6}	---	0.011	0.2	100	0.07	0.018	100	I	100	0.018	0.088
$_{47}Ag$	107*m*	44.3s	1.57×10^{-2}	---	<0.2	0	0	0	0.094	100	I	100	0.094	0.094
	107	Stable	0	30	0.2	0	0	0	0	0	---	---	0	0
	109*m*	39.2s	1.77×10^{-2}	---	0.028	0	0	0	0.088	100	I	100	0.088	0.088
	109	Stable	0	2 + 82	0.028	0	0	0	0	0	---	---	0	0
	110*m*	270d	2.98×10^{-8}	---	2×10^{-7}[a]	0.087	58	0.128	1.516	---	I	~3	~2.6[d]	2.7[d]
						0.530	35		1.389	---	II	~295		
						2.12	3		0.935	---	III	~50		
						2.86	3		0.885	---				
									0.814	---				
									0.759	---				
									0.706	---				
									0.676	---				
									0.656	---				
									0.116	---				
	110	24.2s	2.86×10^{-2}	---	6×10^{-9}	2.16	60	0.811	0.66	100	II	100	0.66	1.48
						2.84	40							
	111	7.6d	1.06×10^{-6}	---	0.018	0.70	8	0.337	0.243	1	I	1	0.030	0.367
						0.80	1		0.340	8	II	8		
						1.04	91							

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	(%)	Av. E_b (Mev)	Gamma Transitions E_g (Mev)	(%)	Shielding Group	(%)	Total E_g (Mev)	Total E (Mev)
$_{47}Ag$	112	3.2h	6.02×10^{-5}	---	0.011	1.0	15	1.04	1.40	---	II	~0	~0[b]	1.04
						2.7	20		0.62	---	III	~0		
						3.5	40							
						4.1	25							
	113	5.3h	3.63×10^{-5}	---	0.01	2.0	100	0.67	0	0	---	---	0	0.67
	114	2m	5.78×10^{-3}	---	0.01	4.11[b]	100	1.37[b]	---	~0	---	---	~0	1.37[b]
	115	20m	5.78×10^{-4}	---	(~0.01)	3.0	100	1.0	0	0	---	---	0	1.0
$_{48}Cd$	110	Stable	0	0.2 + ?	2×10^{-7}	0	0	0	0	0	---	---	0	0
	111	Stable	0	---	0.018	0	0	0	0	0	---	---	0	0
	112	Stable	0	0.02 + ?	0.011	0	0	0	0	0	---	---	0	0
	113m	5.1y	4.30×10^{-9}	---	?	0.59	100	0.20	0	0	---	---	0	0.20
	113	Stable	0	25,000	0.01	0	0	0	0	0	---	---	0	0
	114	Stable	0	0.14 + 1.1	0.01	0	0	0	0	0	---	---	0	0
	115	43d	1.86×10^{-7}	---	0.00071	0.7	2	0.53	1.28	---	II	~0	0.05[d]	0.58[d]
						1.61	98		0.96	---	III	~0		
									0.50	---				
									0.46	---				
	115	53h	3.63×10^{-6}	---	0.0098	0.58	42	0.296	0.525	---	II	42	0.56[d]	0.86[d]
						1.11	58		0.50	---				
									0.360	---				
	116	Stable	0	1.4 + ?	0.01[a]	0	0	0	0	0	---	---	0	0
	117m	2.9h	6.66×10^{-5}	---	0.01	---	<10	---	2.00	---	II	>90	<0.79[b]	<0.79[b]
									1.55	---	III	~0		
									1.27	---	IV	~0		
									0.84	---				
									0.43	---				
									0.33	---				
									0.28	---				
									0.27	---				
	117	50m	2.31×10^{-4}	---	0.010	~1.6	---	<0.79[b]	---	~0	---	---	~0	<0.8[b]
						~3.0	---							
	118	~30m	3.85×10^{-4}	---	0.01	1.09[b]	100	0.36[b]	---	~0	---	---	~0	0.36[b]
$_{49}In$	113	Stable	0	60 + 2	?	0	0	0	0	0	---	---	0	0
	115m	4.50h	4.28×10^{-5}	---	0.0098	0.83	6	0.017	0.335	94	II	94	0.317	0.334
	115	6×10^{14}y	3.66×10^{-23}	145 + 52	0.0099	0.63	100	0.21	0	~0	---	---	~0	0.21
	117m	1.90h	1.01×10^{-4}	---	0.010	1.62	23	0.449	0.311	22	II	22	0.194	0.643
						1.77	55		0.161	78	I	78		
	117	1.1h	1.75×10^{-4}	---	2×10^{-3}	0.740	100	0.247	0.565	---	I	~10	0.09[b]	0.34[b]
									0.161	---	II	~15		
	118	4.5m	2.57×10^{-3}	---	0.01	1.5	100	0.5	?	---	---	---	?	~0.5
	119	17.5m	6.60×10^{-4}	---	0.01	2.7	100	0.9	0	0	---	---	0	0.9

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles: E_b (Mev)	Beta Particles: (%)	Beta Particles: Av. E_b (Mev)	Gamma Transitions: E_g (Mev)	Gamma Transitions: (%)	Gamma Transitions: Shielding: Group	Gamma Transitions: Shielding: (%)	Gamma Transitions: Total E_g (Mev)	Total E (Mev)
$_{50}Sn$	115	Stable	0	---	0.01	0	0	0	0	0	---	---	0	0
	117*m*	14.0d	5.73×10^{-7}	---	$<2 \times 10^{-5}$	0	0	0	0.162	100	I	200	0.321	0.321
									0.159	100				
	117	Stable	0	---	0.010	0	0	0	0	0	---	---	0	0
	118	Stable	0	0.01 + ?	0.01	0	0	0	0	0	---	---	0	0
	119*m*	275d	2.91×10^{-8}	---	<0.01	0	0	0	0.0653	100	I	200	0.0895	0.09
									0.0242	100				
	119	Stable	0	---	0.01	0	0	0	0	0	---	---	0	0
	120	Stable	0	~0.001 + 0.03	0.01[a]	0	0	0	0	0	---	---	0	0
	121	27.5h	7.00×10^{-6}	1.2×10^{-2}	0.014	0.383	100	0.128	0	0	---	---	0	0.128
	122	Stable	0	0.001 + 0.1	0.013[a]	0	0	0	0	0	---	---	0	0
	123	131d	6.12×10^{-8}	---	0.0012	1.42	100	0.47	0	0	---	---	0	0.47
	123	39.5m	2.92×10^{-4}	---	0.014	1.26	100	0.42	0.153	100	I	100	0.153	0.57
	124	Stable	0	0.75	0.02[a]	0	0	0	0	0	---	---	0	0
	125	9.4d	8.53×10^{-7}	---	0.012	0.40	5	0.76	1.90	5	IV	5	0.095	0.86
						2.37	95							
	125	9.5m	1.22×10^{-3}	---	0.011	0.51	---	~0.7	0.326	100	II	100	0.326	~1.03
						1.17	---							
						2.04	~100							
	126	50m	2.31×10^{-4}	---	0.1	2.55[b]	100	0.85[b]	---	~0	---	---	~0	0.85[b]
	127	1.5h	1.28×10^{-4}	---	(0.24)	4.84[b]	100	1.61[b]	---	~0	---	---	~0	1.61[b]
$_{51}Sb$	121	Stable	0	5.7	0.014	0	0	0	0	0	---	---	0	0
	123	Stable	0	0.03 + 0.03 + 2.5	0.015	0	0	0	0	0	---	---	0	0
	125	2.7y	8.14×10^{-9}	---	0.023	0.125	29	0.102	0.637	---	I	28	0.46[d]	0.56[d]
						0.300	45		0.601	---	II	72		
						0.414	12		0.465	---				
						0.612	14		0.425	---				
									0.175	---				
									0.110	---				
									0.035	---				
	126	9h	2.14×10^{-5}	---	0.10	1.0	100	0.33	0.90	100	II	200	1.3	1.63
									0.4	100				
	127	93h	2.07×10^{-6}	---	0.25	1.2	100	0.4	0.72	100	II	100	0.72	1.12
					(0.01)[a]									
	128	1.1h	1.75×10^{-4}	---	0.5	5.68[b]	100	1.9[b]	---	~0	---	---	~0	1.9[b]
	129	4.6h	4.32×10^{-5}	---	1.0	4.42[b]	100	1.5[b]	---	~0	---	---	~0	1.5[b]
	130	12m	9.63×10^{-4}	---	2.0	6.68[b]	100	2.2[b]	---	~0	---	---	~0	2.2[b]
	131	21.0m	5.50×10^{-4}	---	(2.7)	5.44[b]	100	1.8[b]	---	~0	---	---	~0	1.8[b]
	132	1.9m	6.08×10^{-3}	---	(3.4)	7.64[b]	100	2.6[b]	---	~0	---	---	~0	2.6[b]
	133	4.1m	2.82×10^{-3}	---	(3.8)	6.41[b]	100	2.1[b]	---	~0	---	---	~0	2.1[b]
	134	45s	1.54×10^{-2}	---	(3.0)	8.57[b]	100	2.9[b]	---	~0	---	---	~0	2.9[b]

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{52}Te$	125m	58d	1.38×10^{-7}	---	3×10^{-3}	0	0	0	0.110	100	I	100	0.110	0.110
	125	Stable	0	1.5	0.023	0	0	0	0	0	---	---	0	0
	126	Stable	0	0.07 + 0.7	0.10	0	0	0	0	0	---	---	0	0
	127m	90d	8.82×10^{-8}	---	0.056	0	0	0	0.0885	100	I	100	0.09	0.09
	127	9.3h	2.07×10^{-5}	---	0.25	0.7	100	0.23	0	0	---	---	0	0.23
	128	Stable	0	0.016 + 0.14	0.5	0	0	0	0	0	---	---	0	0
	129m	33d	2.43×10^{-7}	---	0.34	0	0	0	0.106	100	I	100	0.106	0.106
	129	72m	1.60×10^{-4}	---	1.0	1.8	100	0.6	0.8	100	II	200	1.1	1.7
									0.3	100				
	130	$> 10^{15}$y	~ 0	<0.01 + 0.3	2.0	0	0	0	0	0	---	---	0	0
	131m	30h	6.42×10^{-5}	---	0.44	0	0	0	0.177	100	I	100	0.177	0.177
	131	24.8m	4.66×10^{-4}	---	2.9	1.4	45	0.577	0.7	45	I	100	0.475	1.052
					(0.2)[a]	2.0	55		0.16	100	II	45		
	132	77h	2.50×10^{-6}	---	4.4	0.22	100	0.073	0.231	100	I	100	0.231	0.961
					(1.0)[a]									
	133m	63m	1.83×10^{-4}	---	4.6	0	0	0	0.4	100	II	100	0.4	0.4
	133	2m	5.78×10^{-3}	---	6.0	1.3	70	0.54	1.0	70	II	170	1.3	1.84
					(2.2)[a]	2.4	30		0.6	100				
	134	44m	2.63×10^{-4}	---	6.7	3.80[b]	100	1.27[b]	---	~ 0	---	---	~ 0	1.27[b]
					(3.7)[a]									
	135	<2m	5.78×10^{-3}	---	(4.2)	5.98[b]	100	2.0[b]	---	~ 0	---	---	~ 0	2.0[b]
$_{53}I$	127	Stable	0	6.1	0.25	0	0	0	0	0	---	---	0	0
	129	1.72×10^{7}y	1.28×10^{-15}	11	1.0	0.15	100	0.05	0.039	100	I	100	0.04	0.09
	131	8.05d	9.96×10^{-7}	600	2.9	0.250	2.8	0.191	0.722	3	II	97.3	0.39	0.58
						0.335	9.3		0.637	9				
						0.608	87.2		0.364	80				
						0.815	0.7		0.284	5.3				
	132	2.4h	8.02×10^{-5}	---	4.4	0.7	15	0.434	2.2	2	II	226	1.992	2.43
						0.9	20		1.96	5	III	19		
						1.16	23		1.40	11	IV	7		
						1.53	24		1.16	8				
						2.12	18		0.96	20				
									0.777	75				
									0.673	100				
									0.624	6				
									0.528	25				
	133	20.8h	9.25×10^{-6}	---	6.5	0.5	6	0.45	1.4	1	II	99	0.555	1.01
					0.5[a]	1.4	94		0.85	5	III	1		
									0.53	94				
	134	52.5m	2.20×10^{-4}	---	7.6	1.5	70	0.60	1.78	~ 35	II	3	~ 1.27	~ 1.92
					0.9[a]	2.5	30		1.10	~ 35	III	35		
									0.86	~ 30	IV	35		
									0.20	~ 0				
									0.12	~ 0				

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Gamma Transitions Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{53}I$	135	6.68h	2.89×10^{-5}	---	5.9	0.5	35	0.308	1.8	~50	III	~50	1.54	1.85
					$(1.7)^a$	1.0	40		1.27	~50	IV	~50		
						1.4	25							
	136	86s	8.06×10^{-3}	---	3.1	3.6	---	~2.1	2.9	---	III	~0	~0	~2.1
						5.0	---		1.38	---	IV	~0		
						6.4	~100		1.38	---				
	137	22.0s	3.15×10^{-2}	---	(4.9)	0.56	100	0.19	0	0	---	---	0	0.19
	138	5.9s	1.17×10^{-1}	---	(3.4)	7.69^b	100	2.56^b	---	~0	---	---	~0	2.56^b
	139	2.7s	2.57×10^{-1}	---	(1.8)	6.48^b	100	2.16^b	---	~0	---	---	~0	2.16^b
$_{54}Xe$	129	Stable	0	45	1.0	0	0	0	0	0	---	---	0	0
					4×10^{-4a}									
	$131m_2$	12.0d	6.68×10^{-7}	---	0.03	0	0	0	0.163	100	I	100	0.163	0.163
	131	Stable	0	120	2.9	0	0	0	0	0	---	---	0	0
	132	Stable	0	? + 0.2	4.4	0	0	0	0	0	---	---	0	0
	$133m$	2.3d	3.49×10^{-6}	---	0.16	0	0	0	0.233	100	I	100	0.233	0.233
	133	5.270d	1.52×10^{-6}	---	6.5	0.345	100	0.115	0.081	100	I	100	0.081	0.196
	134	Stable	0	? + 0.2	7.6	0	0	0	0	0	---	---	0	0
	$135m$	15.6m	7.40×10^{-4}	---	1.8	0	0	0	0.52	100	II	100	0.52	0.52
	135	9.13h	2.11×10^{-5}	2.8×10^6	6.2	0.548	5	0.302	0.60	4	I	96	0.268	0.570
					0.3^a	0.910	95		0.37	1	II	5		
									0.250	96				
	136	Stable	0	0.15	6.3	0	0	0	0	0	---	---	0	0
					3.2^a									
	137	3.9m	2.96×10^{-3}	---	(5.9)	4.0	100	1.33	0	0	---	---	0	1.33
					$(1.3)^a$									
	138	17m	6.79×10^{-4}	---	(5.5)	3.02^b	100	1.0^b	---	~0	---	---	~0	1.0^b
					$(2.1)^a$									
	139	41s	1.69×10^{-2}	---	(4.7)	5.15^b	100	1.7^b	---	~0	---	---	~0	1.7^b
					$(2.9)^a$									
	140	16s	4.33×10^{-2}	---	(3.7)	3.97^b	100	1.3^b	---	~0	---	---	~0	1.3^b
	141	1.7s	4.08×10^{-1}	---	(1.8)	6.07^b	100	2.0^b	---	~0	---	---	~0	2.0^b
	143	1s	6.93×10^{-1}	---	(0.2)	6.95^b	100	2.3^b	---	~0	---	---	~0	2.3^b
	144	1s	6.93×10^{-1}	---	(~0)	5.78^b	100	1.9^b	---	~0	---	---	~0	1.9^b
$_{55}Cs$	133	Stable	0	0.16 + 26	6.5	0	0	0	0	0	---	---	0	0
	135	3.0×10^6y	7.33×10^{-15}	15	6.2	0.21	100	0.07	0	0	---	---	0	0.07
	136	13d	6.17×10^{-7}	---	6×10^{-3a}	0.35	100	0.12	0.9	100	II	100	0.9	1.02
	137	26.6y	8.27×10^{-10}	<2	5.9	0.523	92	0.192	0	0	---	---	0	0.19
						1.17	8							
	138	32m	3.62×10^{-4}	8.7	5.8	2.0	33	1.08	1.44	100	II	100	2.01	3.09
						2.9	10		0.98	43	III	100		
						3.4	67		0.463	33				
	139	9.5m	1.22×10^{-3}	---	(5.9)	3.82^b	100	1.3^b	---	~0	---	---	~0	1.3^b
					$(1.2)^a$									

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{55}Cs$	140	66s	1.05×10^{-2}	0.63	(6.0)	5.93[b]	100	2.0[b]	---	~0	---	---	~0	2.0[b]
					(2.3)[a]									
	141	Short	---	---	(4.7)	4.75[b]	100	1.6[b]	----	~0	---	---	~0	1.6[b]
					(2.9)[a]									
	142	~1m	1.16×10^{-2}	1.76	(3.4)	6.83[b]	100	2.3[b]	---	~0	---	---	~0	2.3[b]
	143	Short	---	---	(1.9)	5.66[b]	100	1.9[b]	0.29	~0	I	~0	~0	1.9[b]
					(1.7)[a]				0.12	~0	II	~0		
	144	Short	---	---	(1.0)[a]	7.72	100	2.6[b]	---	~0	---	---	~0	2.6[b]
$_{56}Ba$	135	Stable	0	5.6	6.2	0	0	0	0	0	---	---	0	0
	136	Stable	0	0.4	6×10^{-3}	0	0	0	0	0	---	---	0	0
	137*m*	2.60m	4.44×10^{-3}	---	5.4	0	0	0	0.661	100	II	100	0.661	0.661
	137	Stable	0	4.9	5.9	0	0	0	0	0	---	---	0	0
	138	Stable	0	0.68	5.8	0	0	0	0	0	---	---	0	0
	139	85m	1.36×10^{-4}	4	6.0	0.82	19	0.220	1.43	19	I	66	0.380	0.600
					(0.1)[a]	2.23	66		0.163	66	III	19		
						2.38	15							
	140	12.80d	6.27×10^{-7}	---	6.3	0.480	40	0.268	0.54	30	I	110	0.237	0.505
					(0.3)[a]				0.30	10	II	40		
						1.022	60		0.16	10				
									0.03	100				
	141	18m	6.42×10^{-4}	---	5.9	2.8	100	0.93	0	0	---	---	0	0.93
					(1.2)[a]									
	142	6m	1.93×10^{-3}	---	(5.6)	2.26[b]	100	0.75[b]	---	~0	---	---	~0	0.75[b]
					(2.2)[a]									
	143	30s	2.31×10^{-2}	---	(4.9)	4.34[b]	100	1.5[b]	---	~0	---	---	~0	1.5[b]
					(3.0)[a]									
	144	Short	---	---	(3.5)	3.18[b]	100	1.1[b]	---	~0	---	---	~0	1.1[b]
					(2.5)[a]									
$_{57}La$	139	Stable	0	8.9	6.0	0	0	0	0	0	---	---	0	0
	140	40.2h	4.79×10^{-6}	3	6.3	1.32	70	0.495	3.0	1	I	1.8	2.11	2.61
						1.67	20		2.5	5.4	II	73.4		
						2.26	10		1.596	94	III	94		
									0.8151	29	IV	6.4		
									0.4867	39				
									0.3286	5.4				
									0.093	1.8				
	141	3.7h	5.20×10^{-5}	---	6.0	0.9	5	0.785	1.5	5	III	5	0.075	0.86
					0.1[a]	2.43	95							
	142	74m	1.56×10^{-4}	---	5.9	2.5	100	0.83	0.87	10	II	100	0.66	1.49
					(0.3)[a]				0.63	90				
	143	19m	6.08×10^{-4}	---	6.2	3.05[b]	100	1.0[b]	---	~0	---	---	~0	1.0[b]
					(1.3)[a]									
	144	Short	---	---	(5.8)	5.12[b]	100	1.7[b]	---	~0	---	---	~0	1.7[b]
					(2.3)[a]									

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{58}Ce$	140	Stable	0	0.6	6.3	0	0	0	0	0	---	---	0	0
	141	32d	2.51×10^{-7}	---	6.0	0.442	67	0.163	0.145	67	I	67	0.097	0.260
						0.581	33							
	142	Stable	0	1.8	5.9	0	0	0	0	0	---	---	0	0
	143	32h	6.01×10^{-6}	---	6.2	0.71	30	0.355	0.660	15.2	I	12.1	0.334	0.689
						1.09	40		0.356	12.1	II	87.9		
						1.39	30		0.289	60.6				
									0.126	12.1				
	144	290d	2.76×10^{-8}	---	6.1	0.170	30	0.087	0.134	~10	I	~50	0.043[d]	0.130[d]
					(0.3)[a]	0.300	70		0.100	~10				
									0.0807	~10				
									0.054	~10				
									0.0337	~10				
	145	3.0m	3.85×10^{-3}	---	4.2	2.67[b]	100	0.89[b]	---	~0	---	---	~0	0.9[b]
	146	13.9m	8.31×10^{-4}	---	(3.2)	0.7	100	0.23	0.32	12	I	72	0.327	0.56
									0.27	24	II	64		
									0.22	36				
									0.142	7				
									0.110	~57				
$_{59}Pr$	141	Stable	0	11	6.0	0	0	0	0	0	---	---	0	0
	143	13.7d	5.85×10^{-7}	---	6.2	0.932	100	0.311	0	0	---	---	0	0.31
	144	17.5m	6.60×10^{-4}	---	6.1	0.8	3	0.97	2.185	1	II	4	0.08	1.05
						2.3	2		1.480	2	III	2		
						2.98	95		0.695	4	IV	1		
	145	6.0h	3.21×10^{-5}	---	4.2	~1.7	100	~0.6	---	~0	---	---	~0	~0.6
	146	24.4m	4.73×10^{-4}	---	3.3	2.2	44	1.01	1.49	33	II	122	1.12	2.13
					(0.1)[a]	3.7	56		0.75	22	III	33		
									0.46	100				
$_{60}Nd$	143	Stable	0	290	6.2	0	0	0	0	0	---	---	0	0
	144	1.5×10^{15}y	~0	4.8	6.1	0	0	0	0	0	---	---	0	0
	145	Stable	0	52	4.2	0	0	0	0	0	---	---	0	0
	146	Stable	0	9.8	3.3	0	0	0	0	0	---	---	0	0
	147	11.3d	7.10×10^{-7}	---	2.6	0.38	25	0.228	0.532	25	I	60	0.236	0.464
						0.60	15		0.318	15	II	40		
						0.83	60		0.092	60				
	148	Stable	0	3.3	1.8[a]	0	0	0	0	0	---	---	0	0
	149	2.0h	9.63×10^{-5}	---	1.3	0.95	---	~0.5	0.650	---	I	~0	~0	~0.5
						1.1	---		0.538	---	II	~0		
						1.5	~100		0.424	---				
									0.266	---				
									0.240	---				

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{60}Nd$ (continued)									0.226	---				
									0.211	---				
									0.198	---				
									0.188	---				
									0.124	---				
									0.114	---				
									0.112	---				
									0.097	---				
									0.030	---				
	150	$>2\times10^{15}$y	~ 0	2.9	0.74[a]	0	0	0	0	0	---	---	0	0
	151	15m	7.7×10^{-4}	---	(0.48)	1.93	100	0.64	1.14	---	I	$\sim$150	0.91[b]	1.55[b]
									0.73	---	II	$\sim$100		
									0.421	---	III	$\sim$50		
									0.117	---				
									0.110	---				
									0.085	---				
$_{61}Pm$	147	2.6y	8.46×10^{-9}	60 + ?	2.6	0.223	100	0.074	0	0	---	---	0	0.074
	149	54h	3.56×10^{-6}	---	1.3	1.05	100	0.35	0.285	100	II	100	0.285	0.635
	151	27.5h	7.00×10^{-6}	---	0.5	1.1	100	0.37	0.715	---	I	$\sim$100	0.5[b]	0.87[b]
					(0.02)[a]				0.340	---	II	$\sim$100		
									<0.25	---				
									0.177	---				
$_{62}Sm$	147	1.4×10^{11}y	~ 0	---	2.6	0	0	0	0	0	---	---	0	0
	149	Stable	0	50,000	1.3	0	0	0	0	0	---	---	0	0
	151	93y	2.37×10^{-10}	12,000	0.5	0.076	100	0.025	0.019	100	I	100	0.019	0.044
	152	Stable	0	150	0.3[a]	0	0	0	0	0	---	---	0	0
	153	47h	4.10×10^{-6}	---	0.15	0.26	10	0.219	0.538	10	I	$\sim$102	0.149	0.368
						0.64	29		0.1717	$\sim$0	II	10		
						0.70	44		0.1026	73				
						0.81	17		0.0691	29				
	154	Stable	0	5.5	0.09[a]	0	0	0	0	0	---	---	0	0
	155	23.5m	4.91×10^{-4}	---	0.031	1.8	100	0.6	0.246	100	I	200	0.35	0.95
									0.105	100				
	156	$\sim$10h	1.93×10^{-5}	---	0.013	0.9	100	0.3	?	?	---	---	?	0.3 ?
$_{63}Eu$	151	Stable	0	1400 + 7000	0.5	0	0	0	0	0	---	---	0	0
	153	Stable	0	400	0.15	0	0	0	0	0	---	---	0	0
	155	1.7y	1.29×10^{-8}	14,000	0.031	0.152	84	0.056	0.1368	---	I	$\sim$500	0.7[b]	0.76[b]
						0.252	16		0.1309	---				
									0.1045	---				
									0.0858	---				
									0.0593	---				
									0.0187	---				

TABLE 2. (continued)

Nuclide	Mass Number, A	Half-life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section σ_a (barns)	Yield, Y (%)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{63}$Eu	156	15.4d	5.21×10^{-7}	---	0.013	0.5	60	0.43	2.0	~60	IV	~60	1.2	1.63
						2.4	40							
	157	15.4h	1.25×10^{-5}	---	0.0074	1.0	75	0.392	0.60	100	I	100	0.8	1.19
						1.7	25		0.2	100	II	100		
	158	60m	1.93×10^{-4}	---	0.002	2.6	100	0.87	---	---	---	---	1.1[b]	2.0[b]
$_{64}$Gd	155	Stable	0	70,000	0.031	0	0	0	0	0	---	---	0	0
	156	Stable	0	---	0.013	0	0	0	0	0	---	---	0	0
	157	Stable	0	160,000	0.0074	0	0	0	0	0	---	---	0	0
	158	Stable	0	4	0.002	0	0	0	0	0	---	---	0	0
	159	18.0h	1.07×10^{-5}	---	1.1×10^{-3}	0.9	100	0.3	0.38	100	I	100	0.46	0.76
									0.055	100	II	100		
	160	Stable	0	1.5	3×10^{-4}[a]	0	0	0	0	0	---	---	0	0
	161	3.6m	3.21×10^{-3}	---	8.0×10^{-5}	1.6	100	0.5	0.36	---	I	100	0.7[b]	1.2[b]
									0.316	---	II	200		
									0.102	---				
$_{65}$Tb	159	Stable	0	44	1.1×10^{-3}	0	0	0	0	0	---	---	0	0
	161	7.0d	1.15×10^{-6}	---	8×10^{-5}	0.5	100	0.17	0.05	100	I	100	0.05	0.22
$_{66}$Dy	161	Stable	0	---	8×10^{-5}	0	0	0	0	0	---	---	0	0

[a]Independent fission yield.
[b]Energy value computed from the mass change.
[c]Nuclide which decays in part by K electron capture and positron emission.
[d]Energy computed from total disintegration energy or Q value.

TABLE 3. PRODUCTS OF NEUTRON CAPTURE BY U^{235} FISSION PRODUCTS

Arranged according to increasing order of atomic number and mass

Nuclide	Mass Number, A	Half life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section, σ_a (barns)	Energy of Radiation: Beta Particles: E_b (Mev)	(%)	Av. E_b (Mev)	Gamma Transitions: E_g (Mev)	(%)	Shielding: Group	(%)	Total E_g (Mev)	Total E (Mev)
$_{33}As$	76	26.6h	7.24×10^{-6}	---	0.35	3	0.842	2.06	2.3	II	49.1	0.460	1.302
					1.20	6		1.41	0.7	III	11.1		
					1.75	6		1.21	10.4	IV	2.3		
					2.40	32		0.648	4.1				
					2.96	53		0.555	45				
$_{34}Se$	76	Stable	0	7 + 75	0	0	0	0	0	---	---	0	0
$_{43}Tc$	100	15.8s	4.39×10^{-2}	---	2.8	100	0.93	0.55	100	II	100	0.55	1.48
$_{44}Ru$	100	Stable	0	---	0	0	0	0	0	---	---	0	0
$_{45}Rh$	104*m*	4.4m	2.63×10^{-3}	---	0	0	0	0.052	100	I	100	0.052	0.052
	104	425s	1.65×10^{-2}	---	2.6	100	0.87	0.95	100	I	100	1.06	1.93
								0.18	50	II	100		
								0.04	50				
$_{46}Pd$	104	Stable	0	---	0	0	0	0	0	---	---	0	0
$_{49}In$	116*m*	54.2m	2.13×10^{-4}	---	0.60	21	0.293	2.090	25	I	3	2.52	2.81
					0.87	28		1.487	21	II	25		
					1.00	51		1.274	75	III	150		
								1.085	54	IV	25		
								0.406	25				
								0.137	3				
	116	13s	4.33×10^{-2}	---	3.29	100	1.10	0	0	---	---	0	1.10
$_{50}Sn$	116	Stable	0	0.006 + ?	0	0	0	0	0	---	---	0	0
$_{51}Sb$	122	2.75d	2.91×10^{-6}	---	0.45	8	0.51	0.566	8	I	36	0.389	0.90
					1.40	56		0.553	56	II	64		
					2.00	36		0.095	36				
$_{52}Te$	122	Stable	0	1.0 + 1.7	0	0	0	0	0	---	---	0	0
$_{53}I$	128[c]	24.98m	4.62×10^{-4}	---	1.59	6.7	0.63	0.428	6.7	II	6.7	0.03	0.66
					2.02	88.3				II	292	2.15	2.42
	130	12.6h	1.53×10^{-5}	---	0.597	54	0.264	1.15	31	III	31		
					1.02	46		0.744	69				
								0.660	100				
								0.528	100				
								0.409	23				

TABLE 3. (continued)

Nuclide	Mass Number, A	Half life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section, σ_a (barns)	Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{54}$Xe	128	Stable	0	5	0	0	0	0	0	---	---	0	0
	130	Stable	0	<5	0	0	0	0	0	---	---	0	0
$_{55}$Cs	134m	3.2h	6.03×10^{-5}	---	0	0	0	0.128	100	I	100	0.128	0.128
	134	2.0y	1.10×10^{-8}	---	0.09	25	0.170	1.365	4	II	206	1.53	1.70
					0.648	75		1.037	6	III	10		
								0.794	96				
								0.601	75				
								0.567	15				
								0.561	20				
$_{56}$Ba	134	Stable	0	2	0	0	0	0	0	-----	---	0	0
$_{59}$Pr	142	19.3h	9.97×10^{-6}	18	0.64	7	0.70	1.59	7	III	7	0.11	0.81
					2.15	93		0.135	~0				
$_{60}$Nd	142	Stable	0	18	0	0	0	0	0	---	---	0	0
$_{61}$Pm	148	5.3d	1.51×10^{-6}	---	2.5	100	0.83	0.8	100	II	100	0.8	1.63
$_{62}$Sm	148	Stable	0	---	0	0	0	0	0	---	---	0	0
	150	Stable	0	---	0	0	0	0	0	---	---	0	0
$_{63}$Eu	152[c]	9.2h	2.09×10^{-5}	---	1.880	100	0.63	0.344	~50	I	~50	~0.23	0.86
								0.122	~50	II	~50		
	152[c]	13y	1.69×10^{-9}	5000	1.58	26	0.137	1.086	---	I	---	---	>0.14
								0.964		II	---	---	
								0.720		III	---	---	
								0.344					
								0.244					
								0.123					
								0.122					
	154[c]	16y	1.38×10^{-9}	1000	0.3	50	0.21	1.116	~50	II	100	1.0[b]	1.2[b]
					0.7	40		0.778	~50	III	50		
					1.9	10		0.336	~50				
$_{64}$Gd	152	Stable	0	<120	0	0	0	0	0	---	---	0	0
	154	Stable	0	---	0	0	0	0	0	---	---	0	0

TABLE 3. (continued)

Nuclide	Mass Number, A	Half life, $t_{1/2}$	Decay Constant, λ (sec^{-1})	Absorption Cross Section, σ_a (barns)	Energy of Radiation: Beta Particles E_b (Mev)	Beta Particles (%)	Beta Particles Av. E_b (Mev)	Gamma Transitions E_g (Mev)	Gamma Transitions (%)	Shielding Group	Shielding (%)	Total E_g (Mev)	Total E (Mev)
$_{65}Tb$	160	73.5d	1.09×10^{-7}	400	0.396	16	0.216	0.962	---	II	150	1.5^b	1.72^b
					0.521	41		0.876	---				
					0.860	43		0.410	---				
								0.391	---				
								0.375	---				
								0.298	---				
								0.282	---				
								0.215	---				
								0.196	---				
								0.176	---				
								0.093	---				
								0.087	---				
$_{66}Dy$	160	Stable	0	0	0	0	0	0	0	---	---	0	0

[a]Independent fission yield.
[b]Energy value computed from the mass change.
[c]Nuclide which decays in part by K electron capture and positron emission.
[d]Energy computed from total disintegration energy or Q value.

TABLE 4. DETERMINATION OF LEVELS OF COMPONENTS OF CHAIN 95 IN 1 TON OF NATURAL URANIUM

Uranium irradiated at $\phi = 10^{14}$ neutrons/cm^2/sec for 3×10^6 sec, then allowed to decay for 10^7 sec

Isotope	Saturation Value, N_s/N_{25}^0, for $\phi = 10^{14}$	Fraction of Saturation, N_τ/N_s, for $\phi = 10^{14}$ neutrons/cm^2/sec and $\tau = 3 \times 10^6$ sec	Atoms Present at Shutdown, $N_\tau/N_{25}^0 = (N_s/N_{25}^0)(N_\tau/N_s)$	Fraction of Shutdown, N_t/N_τ, at $\phi = 10^{14}$ neutrons/cm^2/sec, $\tau = 3 \times 10^6$ sec, and $t = 10^7$ sec	Atoms Present at $\phi = 10^{14}$, $\tau = 3 \times 10^6$, and $t = 10^7$: $N_t/N_{25}^0 = (N_\tau/N_{25}^0)(N_t/N_\tau)$	$N_t = (N_{25}^0)(N_t/N_{25}^0)$
10.5m Y	3.37×10^{-6} (Fig. A-3*f*)	1.00 (Table 4)	3.37×10^{-6}	0 (Fig. C-8)	0	0
63d Zr	2.92×10^{-2} (Fig. A-2*e*)	0.317 (Fig. B-16)	9.26×10^{-3}	0.281 (Fig. C-50)	2.60×10^{-3}	4.78×10^{22}
90h Nb^m	1.73×10^{-5} (Fig. A-2*c*)	0.274 (Fig. B-16)	4.75×10^{-6}	1.06 (Fig. C-47)	5.04×10^{-6}	9.27×10^{19}
35d Nb	1.62×10^{-2} (Fig. A-2*a*)	9.23×10^{-2} (Fig. B-16)	1.50×10^{-3}	1.45 (Fig. C-48)	2.18×10^{-3}	4.01×10^{22}
Stable Mo			3.73×10^{-4} (Fig. D-27)		6.36×10^{-3}*	1.17×10^{23}
Total			1.114×10^{-2}		1.114×10^{-2}	2.05×10^{23}

*N_t/N_{25}^0 for stable Mo^{95} was computed by taking into account that the total number of fission product atoms does not change during decay times. Thus, $N_t/N_{25}^0 = 1.114 \times 10^{-2} - (2.60 \times 10^{-3} + 5.04 \times 10^{-6} + 2.18 \times 10^{-3}) = 6.4 \times 10^{-3}$.

TABLE 5. INDEX OF FISSION PRODUCTS AND GRAPHS

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0 at $\phi = 10^{12}$	Saturation Values, N_s/N_{25}^0 at $\phi \geqq 10^{12}$	Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
72	49.0h Zn	2.21×10^{-11}	Fig. A-3*f*	Fig. B-1	Fig. C-28	
	14.3h Ga	6.44×10^{-12}	Fig. A-4	Fig. B-1	Fig. C-31	
	Stable Ge					Fig. D-1
73	2m Zn	9.83×10^{-14}	Fig. A-4	Unity	Fig. C-4	
	5.0h Ga	1.51×10^{-11}	Fig. A-3	Unity	Fig. C-19	
	Stable Ge					Fig. D-2
74	Stable Ge					Fig. D-3
75	82m Ge	3.29×10^{-11}	Fig. A-3	Unity	Fig. C-12	
	Stable As					Fig. D-4
76	Stable Ge					Fig. D-5
	26.6h As*	6.41×10^{-10}	Fig. A-3*f*	Fig. B-7	Fig. C-28	
	Stable Se^{76*}					Fig. D-6
77	12h Ge	1.34×10^{-9}	Fig. A-3	Fig. B-3	Fig. C-19	
	38.8h As	1.06×10^{-8}	Fig. A-3*f*	Fig. B-2	Fig. C-23	
	17.5s Se^m	2.67×10^{-14}	Fig. A-4	Fig. B-2	Fig. C-23	
	Stable Se					Fig. D-7
78	86m Ge	7.79×10^{-10}	Fig. A-3	Unity	Fig. C-10	
	91m As	9.13×10^{-10}	Fig. A-3*f*	Unity	Fig. C-14	
	Stable Se					Fig. D-8
79	9m As	1.81×10^{-10}	Fig. A-3*f*	Unity	Fig. C-4	
	3.9m Se^m	7.03×10^{-11}	Fig. A-3*f*	Unity	Fig. C-7	
	6.5×10^4y Se	0.686	Fig. A-1	Fig. B-8		
80	Stable Se					Fig. D-9
81	10m As	6.25×10^{-10}	Fig. A-3*g*	Unity	Fig. C-6	
	56.5m Se^m	2.27×10^{-10}	Fig. A-3	Unity	Fig. C-10	
	17m Se	1.75×10^{-10}	Fig. A-3*a*	Unity	Fig. C-11	
	Stable Br					Fig. D-10

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0 at $\phi = 10^{12}$	Saturation Values, N_s/N_{25}^0 at $\phi \geqq 10^{12}$	Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
82	Stable Se					Fig. D-11
	35.87h Br	1.44×10^{-7}	Fig. A-2*e*	Fig. B-9	Fig. C-28	
	Stable Kr					Fig. D-12
83	25m Se	2.26×10^{-9}	Fig. A-3	Unity	Fig. C-6	
	2.4h Br	3.47×10^{-8}	Fig. A-3*f*	Unity	Fig. C-11	
	114m Kr^m	2.76×10^{-8}	Fig. A-3	Unity	Fig. C-11	
	Stable Kr					Fig. D-13
84	2m Se	1.10×10^{-9}	Fig. A-3*g*	Unity	Fig. C-4	
	30m Br	1.66×10^{-8}	Fig. A-3	Unity	Fig. C-6	
	Stable Kr					Fig. D-14
85	3.0m Br	2.26×10^{-9}	Fig. A-3	Unity	Fig. C-5	
	4.36h Kr^m	1.97×10^{-7}	Fig. A-2	Unity	Fig. C-19	
	10.27y Kr	8.07×10^{-4}	Fig. A-2*f*	Fig. B-10	Fig. C-56, 56*a*	
	Stable Rb					Fig. D-15
86	Stable Kr					Fig. D-16
	19.5d Rb	2.11×10^{-5}	Fig. A-2*d*	Fig. B-11	Fig. C-45	
	Stable Sr					Fig. D-17
87	55.6s Br	1.25×10^{-9}	Fig. A-3*f*	Unity	Fig. C-3	
	78m Kr	1.06×10^{-7}	Fig. A-2	Unity	Fig. C-10	
	Stable Rb					Fig. D-18
	Stable Sr*					Fig. D-19
88	15.5s Br	3.76×10^{-10}	Fig. A-3*e*	Unity	Fig. C-2	
	2.77h Kr	3.09×10^{-7}	Fig. A-2*a*	Unity	Fig. C-10	
	17.8m Rb	3.31×10^{-8}	Fig. A-3*g*	Unity	Fig. C-10	
	Stable Sr					Fig. D-20
89	3.18m Kr	7.35×10^{-9}	Fig. A-3*g*	Unity	Fig. C-4	
	15.4m Rb	3.71×10^{-8}	Fig. A-3*b*	Unity	Fig. C-7	
	54d Sr	1.88×10^{-4}	Fig. A-2*f*	Fig. B-12	Fig. C-45	
	Stable Y					Fig. D-21

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0 at $\phi = 10^{12}$	Saturation Values, N_s/N_{25}^0 at $\phi \geqq 10^{12}$	Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
90	33s Kr	1.44×10^{-9}	Fig. A-3*b*	Unity	Fig. C-3	
	2.74m Rb	8.11×10^{-9}	Fig. A-3	Unity	Fig. C-4	
	28y Sr	4.36×10^{-2}	Fig. A-1*a*	Fig. B-13	Fig. C-59	
	64.5h Y	2.08×10^{-5}	Fig. A-2*d*	Fig. B-14	Fig. C-58, 58*g*	
	Stable Zr					Fig. D-22
91	14m Rb	4.01×10^{-8}	Fig. A-3	Unity	Fig. C-9	
	9.7h Sr	1.72×10^{-6}	Fig. A-2	Fig. B-6	Fig. C-19	
	51m Y^m	6.06×10^{-8}	Fig. A-3	Fig. B-6	Fig. C-21	
	58d Y	2.48×10^{-4}	Fig. A-2*c*	Fig. B-15	Fig. C-46, 46*a*	
	Stable Zr					Fig. D-23
92	3.0s Kr	6.78×10^{-11}	Fig. A-3*a*	Unity	Fig. C-1	
	80s Rb	3.68×10^{-9}	Fig. A-3	Unity	Fig. C-3	
	2.7h Sr	4.96×10^{-7}	Fig. A-2	Unity	Fig. C-12	
	3.60h Y	6.61×10^{-7}	Fig. A-2*c*	Unity	Fig. C-16	
	Stable Zr					Fig. D-24
93	7m Sr	2.25×10^{-8}	Fig. A-3*a*	Unity	Fig. C-4	
	10.0h Y	1.95×10^{-6}	Fig. A-2*b*	Fig. B-6	Fig. C-20	
	Stable Zr					Fig. D-25
94	2m Sr	5.82×10^{-9}	Fig. A-3*f*	Unity	Fig. C-4	
	16.5m Y	5.39×10^{-8}	Fig. A-3*f*	Unity	Fig. C-9*a*	
	Stable Zr					Fig. D-26
95	10.5m Y	3.37×10^{-8}	Fig. A-3*f*	Unity	Fig. C-8	
	63d Zr	2.92×10^{-4}	Fig. A-2*e*	Fig. B-16	Fig. C-50	
	90h Nb^m	1.73×10^{-7}	Fig. A-2*c*	Fig. B-16	Fig. C-47	
	35d Nb	1.62×10^{-4}	Fig. A-2*a*	Fig. B-16	Fig. C-48	
	Stable Mo					Fig. D-27
96	Stable Zr					Fig. D-28
	23.4h Nb	4.02×10^{-10}	Fig. A-3	Fig. B-3	Fig. C-28	
	Stable Mo					Fig. D-29

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0		Fraction of Saturation, N_T/N_s	Fraction of Shutdown, N_t/N_T	Production of Stable Species During Irradiation, N_T/N_{25}^0
		at $\phi = 10^{12}$	at $\phi \gtrless 10^{12}$			
97	17h Zr	3.18×10^{-6}	Fig. A-2	Fig. B-6	Fig. C-28	
	60s Nb^m	3.1×10^{-9}	Fig. A-3*f*	Fig. B-6	Fig. C-28	
	72.1m Nb	2.25×10^{-7}	Fig. A-2*b*	Fig. B-3	Fig. C-27	
	Stable Mo					Fig. D-30
98	Stable Mo					Fig. D-31
99	67h Mo	1.23×10^{-5}	Fig. A-2	Fig. B-2	Fig. C-36	
	6.04h Tc^m	1.11×10^{-7}	Fig. A-2*b*	Fig. B-2	Fig. C-30	
	Stable Tc					Fig. D-32
100	Stable Mo					Fig. D-33
	Stable Ru*					Fig. D-34
101	14.6m Mo	3.67×10^{-8}	Fig. A-3*b*	Unity	Fig. C-6	
	14.0m Tc	3.52×10^{-8}	Fig. A-3*f*	Unity	Fig. C-9*a*	
	Stable Ru					Fig. D-35
102	12m Mo	2.53×10^{-8}	Fig. A-3*b*	Unity	Fig. C-6	
	25s Tc	8.79×10^{-10}	Fig. A-3*a*	Unity	Fig. C-6	
	Stable Ru					Fig. D-36
103	41d Ru	8.58×10^{-5}	Fig. A-2*e*	Fig. B-17	Fig. C-45	
	57m Rh^m	7.47×10^{-8}	Fig. A-3*a*	Fig. B-17	Fig. C-45	
	Stable Rh					Fig. D-37
104	Stable Ru					Fig. D-38
	Stable Pd*					Fig. D-39
105	4.5h Ru	1.22×10^{-7}	Fig. A-2*c*	Unity	Fig. C-20	
	45s Rh^m	3.39×10^{-10}	Fig. A-3*a*	Unity	Fig. C-20	
	36.5h Rh	9.91×10^{-7}	Fig. A-2	Fig. B-3	Fig. C-24	
	Stable Pd					Fig. D-40
106	1.0y Ru	1.00×10^{-4}	Fig. A-2*b*	Fig. B-15	Fig. C-53	
	30s Rh	9.54×10^{-11}	Fig. A-3	Fig. B-15	Fig. C-53	
	Stable Pd					Fig. D-41

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0 at $\phi = 10^{12}$	at $\phi \geqq 10^{12}$	Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
107	1.5m Tc	1.21×10^{-10}	Fig. A-3*f*	Unity	Fig. C-3	
	4m Ru	4.01×10^{-10}	Fig. A-3	Unity	Fig. C-5	
	26m Rh	2.61×10^{-9}	Fig. A-3*a*	Unity	Fig. C-7	
	Stable Pd					Fig. D-42
108	Stable Pd					Fig. D-43
109	1h Rh	8.41×10^{-10}	Fig. A-3*b*	Unity	Fig. C-12	
	13.6h Pd	4.41×10^{-8}	Fig. A-3*a*	Fig. B-18	Fig. C-20	
	39.2s Ag^m	3.54×10^{-11}	Fig. A-3*g*	Fig. B-18	Fig. C-20	
	Stable Ag					Fig. D-44
110	Stable Pd					Fig. D-45
	270d Ag^{m*}	5.45×10^{-6}	Fig. A-2	Fig. B-19	Fig. C-53	
	Stable Cd*					Fig. D-46
111	22m Pd	1.99×10^{-10}	Fig. A-3*g*	Unity	Fig. C-6	
	7.6d Ag	9.85×10^{-8}	Fig. A-3	Unity	Fig. C-36	
	Stable Cd					Fig. D-47
112	21h Pd	6.96×10^{-9}	Fig. A-3*b*	Fig. B-4	Fig. C-28	
	3.2h Ag	1.06×10^{-9}	Fig. A-4*a*	Fig. B-4	Fig. C-22	
	Stable Cd					Fig. D-48
113	5.3h Ag	1.60×10^{-9}	Fig. A-3*a*	Unity	Fig. C-20	
	Stable Cd					Fig. D-49
114	2m Ag	1.01×10^{-11}	Fig. A-3*b*	Unity	Fig. C-4	
	Stable Cd					Fig. D-50
115	20m Ag	1.06×10^{-10}	Fig. A-3*b*	Unity	Fig. C-8	
	53h Cd	1.68×10^{-8}	Fig. A-3*g*	Fig. B-5	Fig. C-29	
	4.5h In^m	1.42×10^{-9}	Fig. A-3*c*	Fig. B-5	Fig. C-25	
	Stable In					Fig. D-51
	Stable Sn					Fig. D-52
116	Stable Cd					Fig. D-53
	Stable Sn					Fig. D-54

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0 at $\phi = 10^{12}$	at $\phi \geqq 10^{12}$	Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
117	2.9h Cd^m	8.71×10^{-10}	Fig. A-3*c*	Unity	Fig. C-12	
	50m Cd	2.51×10^{-10}	Fig. A-3*b*	Unity	Fig. C-12	
	1.90h In^m	5.74×10^{-10}	Fig. A-3*b*	Unity	Fig. C-17	
	1.1h In	7.29×10^{-11}	Fig. A-3*d*	Unity	Fig. C-17	
	Stable Sn					Fig. D-55
118	30m Cd	1.51×10^{-10}	Fig. A-3*d*	Unity	Fig. C-9	
	4.5m In	2.26×10^{-11}	Fig. A-3*a*	Unity	Fig. C-9	
	Stable Sn					Fig. D-56
119	17.5m In	8.79×10^{-11}	Fig. A-3*g*	Unity	Fig. C-9	
	275d Sn^{m*}	1.99×10^{-6}	Fig. A-2*c*	Fig. B-20	Fig. C-51	
	Stable Sn					Fig. D-57
120	Stable Sn					Fig. D-58
121	27.5h Sn	1.16×10^{-8}	Fig. A-3*a*	Fig. B-3	Fig. C-29	
	Stable Sb					Fig. D-59
122	Stable Sn					Fig. D-60
	2.75d Sb*	2.79×10^{-8}	Fig. A-3	Fig. B-21	Fig. C-36	
	Stable Te*					Fig. D-61
123	131d Sn	1.14×10^{-7}	Fig. A-2*d*	Fig. B-22	Fig. C-50	
	39.5m Sn	2.78×10^{-10}	Fig. A-3*c*	Unity	Fig. C-10	
	Stable Sb					Fig. D-62
124	Stable Sn					Fig. D-63
125	9.4d Sn^m	1.56×10^{-7}	Fig. A-2*d*	Fig. B-1	Fig. C-36	
	2.7y Sb	1.64×10^{-5}	Fig. A-2*b*	Fig. B-15	Fig. C-54, 54*a*	
	58d Te^m	1.35×10^{-7}	Fig. A-2*a*	Fig. B-22	Fig. C-52, 52*a*	
	Stable Te					Fig. D-64
126	50m Sn	2.51×10^{-9}	Fig. A-3*g*	Unity	Fig. C-10	
	9h Sb	2.71×10^{-8}	Fig. A-3*c*	Fig. B-4	Fig. C-21	
	Stable Te					Fig. D-65

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N^0_{25} at $\phi = 10^{12}$	at $\phi \geq 10^{12}$	Fraction of Saturation, N_T/N_s	Fraction of Shutdown, N_t/N_T	Production of Stable Species During Irradiation, N_T/N^0_{25}
127	1.5h Sn	1.09×10^{-8}	Fig. A-3*f*	Unity	Fig. C-12	
	93h Sb	7.00×10^{-7}	Fig. A-2*b*	Fig. B-5	Fig. C-32	
	90d Te^m	3.68×10^{-6}	Fig. A-2*b*	Fig. B-23	Fig. C-49	
	9.3h Te	7.00×10^{-8}	Fig. A-3*b*	Fig. B-23	Fig. C-41, 41*a*, 41*b*	
	Stable I					Fig. D-66
128	1.1h Sb	1.66×10^{-8}	Fig. A-3	Unity	Fig. C-12	
	Stable Te					Fig. D-67
	Stable Xe*					Fig. D-63
129	4.6h Sb	1.34×10^{-7}	Fig. A-2*a*	Unity	Fig. C-20	
	33d Te^m	8.12×10^{-6}	Fig. A-2*b*	Fig. B-24	Fig. C-42, 42*a*	
	72m Te	3.62×10^{-8}	Fig. A-3*b*	Fig. B-24	Fig. C-43, 43*a*	
	Stable I					Fig. D-69
	Stable Xe					Fig. D-70
130	12m Sb	1.20×10^{-8}	Fig. A-3*d*	Unity	Fig. C-8	
	Stable Te					Fig. D-71
	12.6 I*	3.79×10^{-7}	Fig. A-2*b*	Fig. B-25	Fig. C-20	
	Stable Xe*					Fig. D-72
131	21m Sb	2.85×10^{-8}	Fig. A-3*d*	Unity	Fig. C-9	
	30h Te^m	3.98×10^{-8}	Fig. A-3	Unity	Fig. C-13	
	24.8m Te	3.61×10^{-8}	Fig. A-3*b*	Unity	Fig. C-15	
	8.05d I	1.69×10^{-5}	Fig. A-2*a*	Fig. B-26	Fig. C-36	
	12d Xe^m	2.52×10^{-7}	Fig. A-2*c*	Fig. B-27	Fig. C-37	
	Stable Xe					Fig. D-73
132	1.9m Sb	3.24×10^{-9}	Fig. A-3*c*	Unity	Fig. C-5	
	77h Te	1.02×10^{-5}	Fig. A-2*c*	Fig. B-28	Fig. C-36	
	2.4h I	3.18×10^{-7}	Fig. A-2*e*	Fig. B-28	Fig. C-33, 33*a*, 33*b*	
	Stable Xe					Fig. D-74
133	63m Te^m	1.90×10^{-7}	Fig. A-2	Unity	Fig. C-10	
	20.8h I	4.08×10^{-6}	Fig. A-2*e*	Fig. B-6	Fig. C-27	
	2.3d Xe^m	2.59×10^{-7}	Fig. A-2*c*	Fig. B-29	Fig. C-34	

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0		Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
		at $\phi = 10^{12}$	at $\phi \gtrapprox 10^{12}$			
133	5.27d Xe	2.48×10^{-5}	Fig. A-2*b*	Fig. B-29	Fig. C-35	
	Stable Cs					Fig. D-75
134	44m Te	1.48×10^{-7}	Fig. A-2*e*	Unity	Fig. C-12	
	52.5m I	2.00×10^{-7}	Fig. A-2*d*	Unity	Fig. C-13	
	Stable Xe					Fig. D-76
	2.0y Cs*	3.43×10^{-3}	Fig. A-1	Fig. B-30	Fig. C-55	
	Stable Ba*					Fig. D-77
135	2m Te	4.21×10^{-9}	Fig. A-3*a*	Unity	Fig. C-4	
	6.68h I	1.18×10^{-6}	Fig. A-2*e*	Fig. B-31	Fig. C-19	
	15.6m Xe^m	1.39×10^{-8}	Fig. A-3*c*	Fig. B-31	Fig. C-21	
	9.2h Xe	1.50×10^{-6}	Fig. A-2*f*	Fig. B-31	Fig. C-18, 18*a*, 18*b*	
	Stable Cs					Fig. D-78
136	86s I	2.23×10^{-9}	Fig. A-3	Unity	Fig. C-3	
	Stable Xe					Fig. D-79
	13d Cs*	5.15×10^{-5}	Fig. A-2*f*	Fig. B-32	Fig. C-45	
	Stable Ba*					Fig. D-80
137	3.9m Xe	1.16×10^{-8}	Fig. A-3*a*	Unity	Fig. C-4	
	26.6y Cs	4.13×10^{-2}	Fig. A-1*a*	Fig. B-33	Fig. C-59	
	2.60m Ba^m	7.07×10^{-9}	Fig. A-3*e*	Fig. B-33	Fig. C-59	
	Stable Ba					Fig. D-81
138	5.9s I	1.69×10^{-10}	Fig. A-3*c*	Unity	Fig. C-2	
	17m Xe	4.70×10^{-8}	Fig. A-3*d*	Unity	Fig. C-8	
	32m Cs	9.32×10^{-8}	Fig. A-4*b*	Fig. B-34	Fig. C-13	
	Stable Ba					Fig. D-82
139	2.7s I	4.06×10^{-11}	Fig. A-3*b*	Unity	Fig. C-1	
	41s Xe	1.61×10^{-9}	Fig. A-3*a*	Unity	Fig. C-3	
	9.5m Cs	2.80×10^{-8}	Fig. A-3	Unity	Fig. C-9	
	85m Ba	2.56×10^{-7}	Fig. A-2*c*	Unity	Fig. C-11	
	Stable La					Fig. D-83

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0 at $\phi = 10^{12}$	Saturation Values, N_s/N_{25}^0 at $\phi \geqq 10^{12}$	Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
140	16s Xe	4.96×10^{-10}	Fig. A-3*c*	Unity	Fig. C-2	
	66s Cs	3.31×10^{-9}	Fig. A-3*b*	Unity	Fig. C-3	
	12.8d Ba	5.83×10^{-5}	Fig. A-2*b*	Fig. B-35	Fig. C-36	
	40.2h La	7.63×10^{-6}	Fig. A-2*e*	Fig. B-35	Fig. C-38	
	Stable Ce					Fig. D-84
141	18m Ba	5.33×10^{-8}	Fig. A-3*g*	Unity	Fig. C-6	
	3.7h La	6.69×10^{-7}	Fig. A-2*c*	Unity	Fig. C-21	
	32d Ce	1.39×10^{-4}	Fig. A-2*c*	Fig. B-36	Fig. C-44, 44*a*	
	Stable Pr					Fig. D-85
142	6m Ba	1.68×10^{-8}	Fig. A-3*g*	Unity	Fig. C-4	
	74m La	2.19×10^{-7}	Fig. A-2*b*	Unity	Fig. C-14	
	Stable Ce					Fig. D-86
	Stable Nd*					Fig. D-87
143	0.5m Ba	1.23×10^{-9}	Fig. A-3*d*	Unity	Fig. C-3	
	19m La	5.91×10^{-8}	Fig. A-3*c*	Unity	Fig. C-6	
	33h Ce	6.17×10^{-6}	Fig. A-2*d*	Fig. B-4	Fig. C-29	
	13.7d Pr	6.15×10^{-5}	Fig. A-2*d*	Fig. B-37	Fig. C-39	
	Stable Nd					Fig. D-88
144	290d Ce	1.28×10^{-3}	Fig. A-1	Fig. B-37	Fig. C-53	
	17.5m Pr	5.36×10^{-8}	Fig. A-3*g*	Fig. B-37	Fig. C-53	
	Stable Nd					Fig. D-89
145	3.0m Ce	6.33×10^{-9}	Fig. A-3*c*	Unity	Fig. C-5	
	6.0h Pr	7.59×10^{-7}	Fig. A-2*d*	Unity	Fig. C-19	
	Stable Nd					Fig. D-90
146	13.9m Ce	2.23×10^{-8}	Fig. A-3*f*	Unity	Fig. C-8	
	24.4m Pr	4.05×10^{-8}	Fig. A-3	Unity	Fig. C-7	
	Stable Nd					Fig. D-91
147	11.3d Nd	2.12×10^{-5}	Fig. A-2	Fig. B-28	Fig. C-36	
	2.6y Pm	1.77×10^{-3}	Fig. A-1*a*	Fig. B-38	Fig. C-55, 55*a*	
	Stable Sm					Fig. D-92

TABLE 5. (continued)

Mass No.	Element and Half life	Saturation Values, N_s/N_{25}^0 at $\phi = 10^{12}$	at $\phi \gtrapprox 10^{12}$	Fraction of Saturation, N_τ/N_s	Fraction of Shutdown, N_t/N_τ	Production of Stable Species During Irradiation, N_τ/N_{25}^0
148	Stable Nd					Fig. D-93
	5.3d Pm*	7.03×10^{-8}	Fig. A-4*a*	Fig. B-39	Fig. C-36	
	Stable Sm*					Fig. D-94
149	2.0h Nd	7.83×10^{-8}	Fig. A-3*f*	Unity	Fig. C-10	
	54h Pm	2.12×10^{-6}	Fig. A-2*e*	Fig. B-29	Fig. C-26	
	Stable Sm					Fig. D-95
150	Stable Nd					Fig. D-96
	Stable Sm*					Fig. D-97
151	15m Nd	3.62×10^{-9}	Fig. A-3	Unity	Fig. C-8	
	27.5h Pm	4.14×10^{-7}	Fig. A-2*d*	Fig. B-6	Fig. C-29	
	93y Sm	2.37×10^{-4}	Fig. A-4*d*	Fig. B-40	Fig. C-60, 60*a*	
	Stable Eu					Fig. D-98
152	Stable Sm					Fig. D-99
	13y Eu*	8.40×10^{-6}	Fig. A-4*c*	Fig. B-41	Fig. C-57	
	Stable Gd*					Fig. D-100
153	47h Sm	6.37×10^{-7}	Fig. A-2*e*	Fig. B-42	Fig. C-29	
	Stable Eu					Fig. D-101
154	Stable Sm					Fig. D-102
	16y Eu*	3.66×10^{-4}	Fig. A-4*d*	Fig. B-43	Fig. C-57	
	Stable Gd*					Fig. D-103
155	23.5m Sm	3.66×10^{-10}	Fig. A-3*e*	Unity	Fig. C-8	
	1.78 Eu	6.68×10^{-6}	Fig. A-4*d*	Fig. B-44	Fig. C-53	
	Stable Gd					Fig. D-104
156	10h Sm	3.91×10^{-9}	Fig. A-3*g*	Fig. B-45	Fig. C-20	
	15.4d Eu	3.24×10^{-7}	Fig. A-4*b*	Fig. B-46, 46*a*	Fig. C-40, 40*a*, 40*b*	
	Stable Gd					Fig. D-105
157	15.4h Eu	3.43×10^{-9}	Fig. A-3*d*	Fig. B-31	Fig. C-20	
	Stable Gd					Fig. D-106

TABLE 5. (concluded)

Mass No.	Element and Half life	Saturation Values, N_s/N^0_{25} at $\phi = 10^{12}$	at $\phi \geqq 10^{12}$	Fraction of Saturation, N_T/N_s	Fraction of Shutdown, N_t/N_T	Production of Stable Species During Irradiation, N_T/N^0_{25}
158	60m Eu	6.01×10^{-11}	Fig. A-3*c*	Unity	Fig. C-12	
	Stable Gd					Fig. D-107
159	18.0h Gd	5.96×10^{-10}	Fig. A-3*d*	Fig. B-45	Fig. C-29	
	Stable Tb					Fig. D-108
160	Stable Gd					Fig. D-109
	73.5d Tb*	5.83×10^{-8}	Fig. A-3*e*	Fig. B-47	Fig. C-50	
	Stable Dy*					Fig. D-110
161	3.6m Gd	1.45×10^{-13}	Fig. A-4	Unity	Fig. C-4	
	7.0d Tb	4.03×10^{-10}	Fig. A-3	Fig. B-17	Fig. C-36	
	Stable Dy					Fig. D-111

APPENDIX B

FIGURES

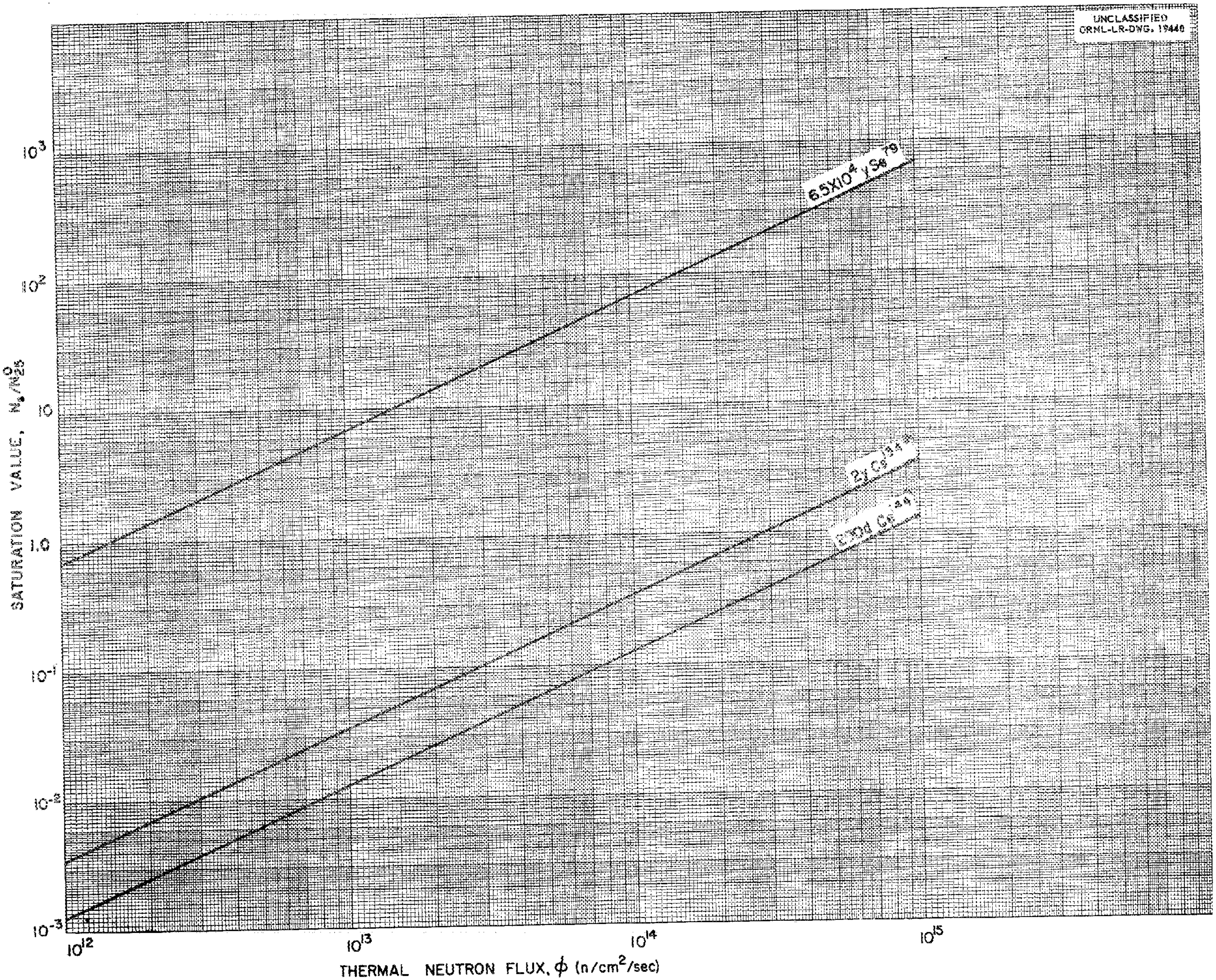

Fig. A-1. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

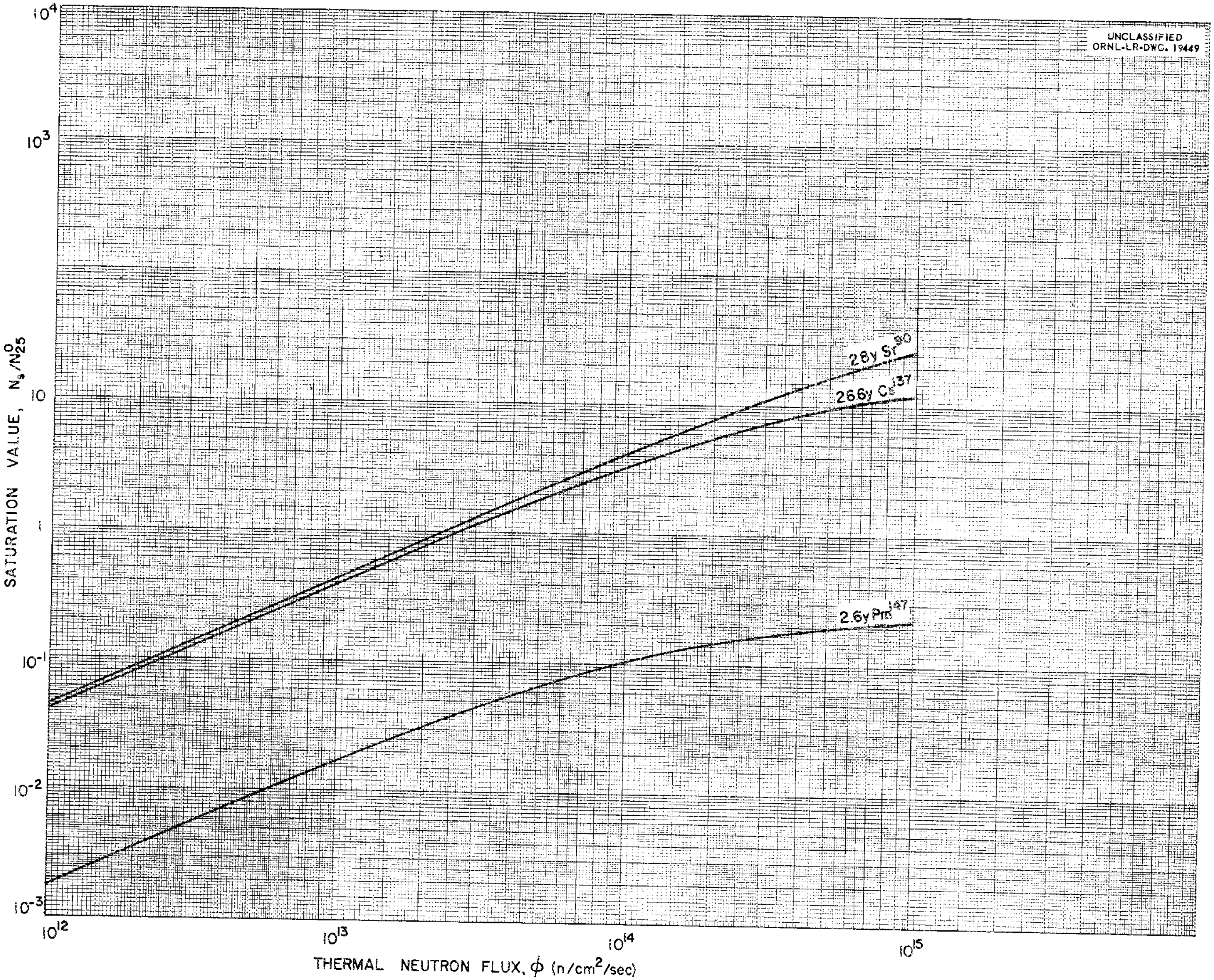

Fig. A-1a. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

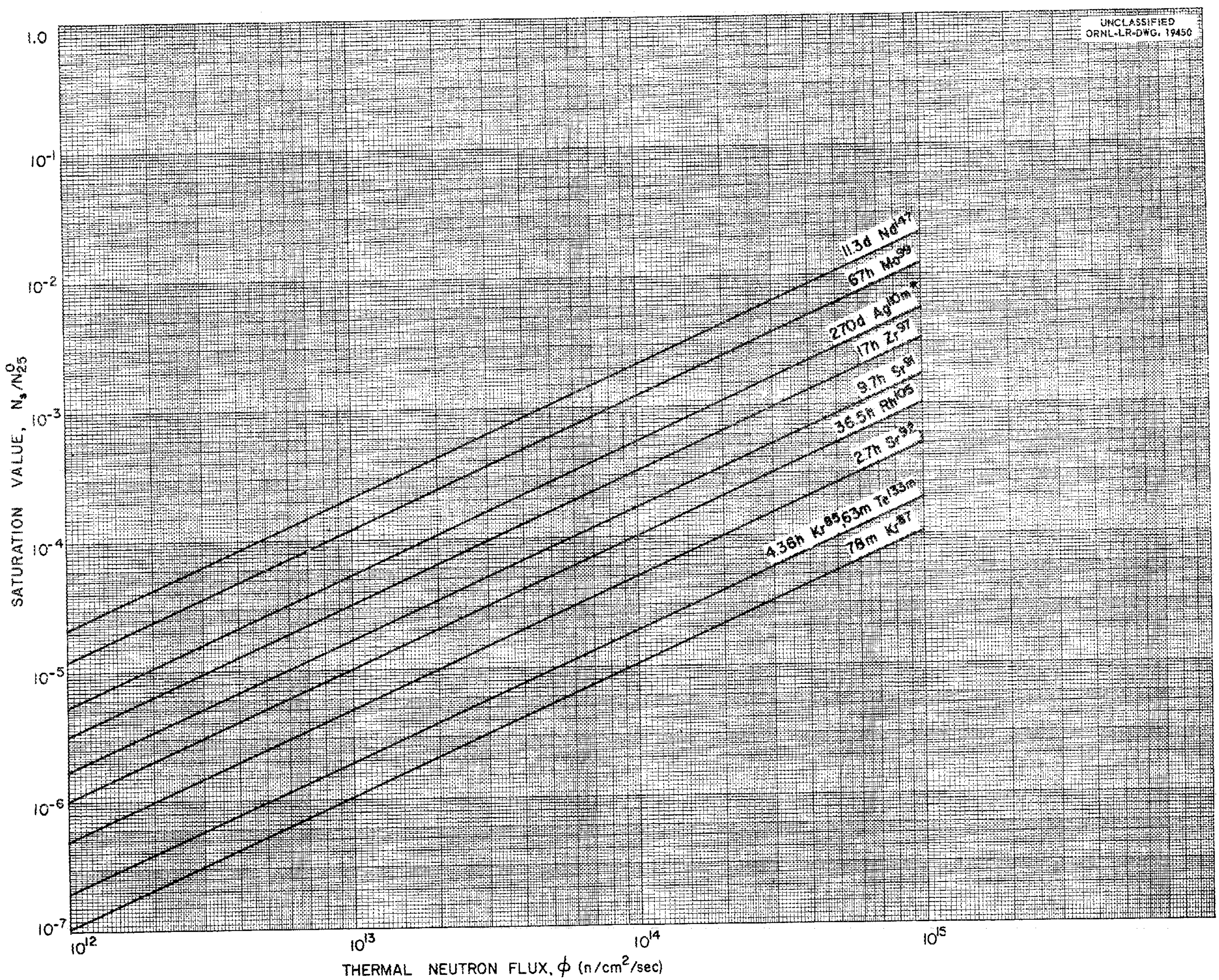

Fig. A-2. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

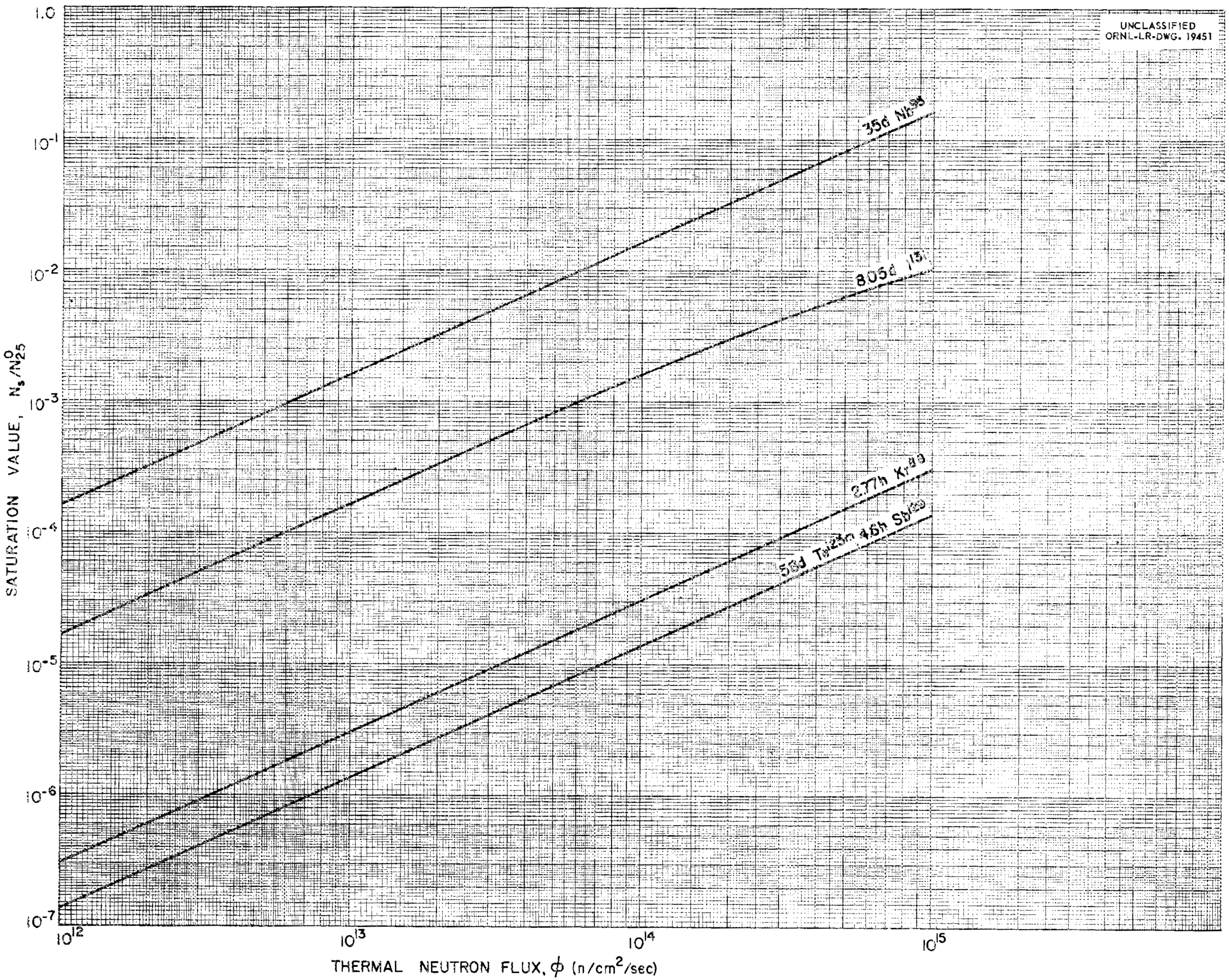

Fig. A-2a. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

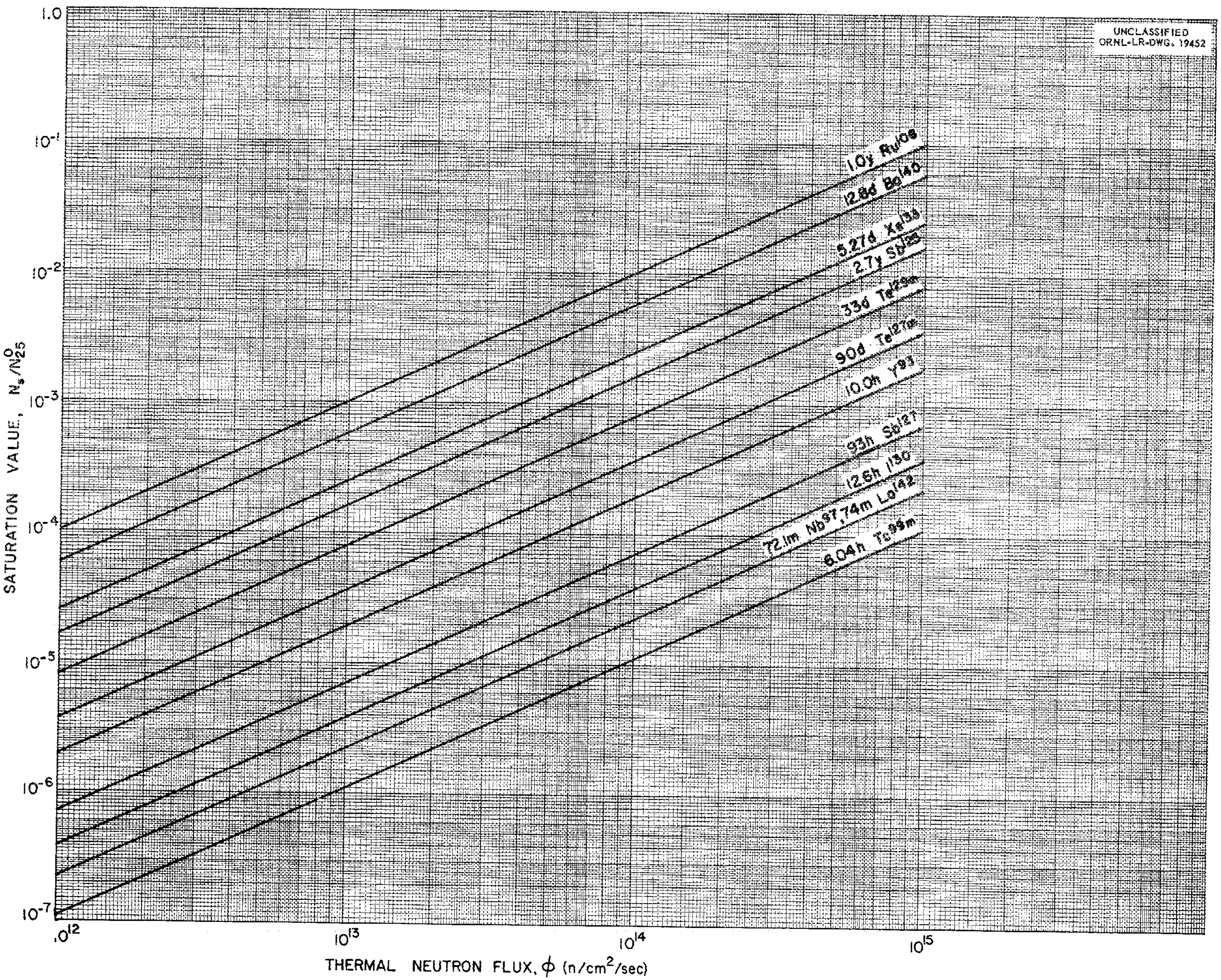

Fig. A-2b. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

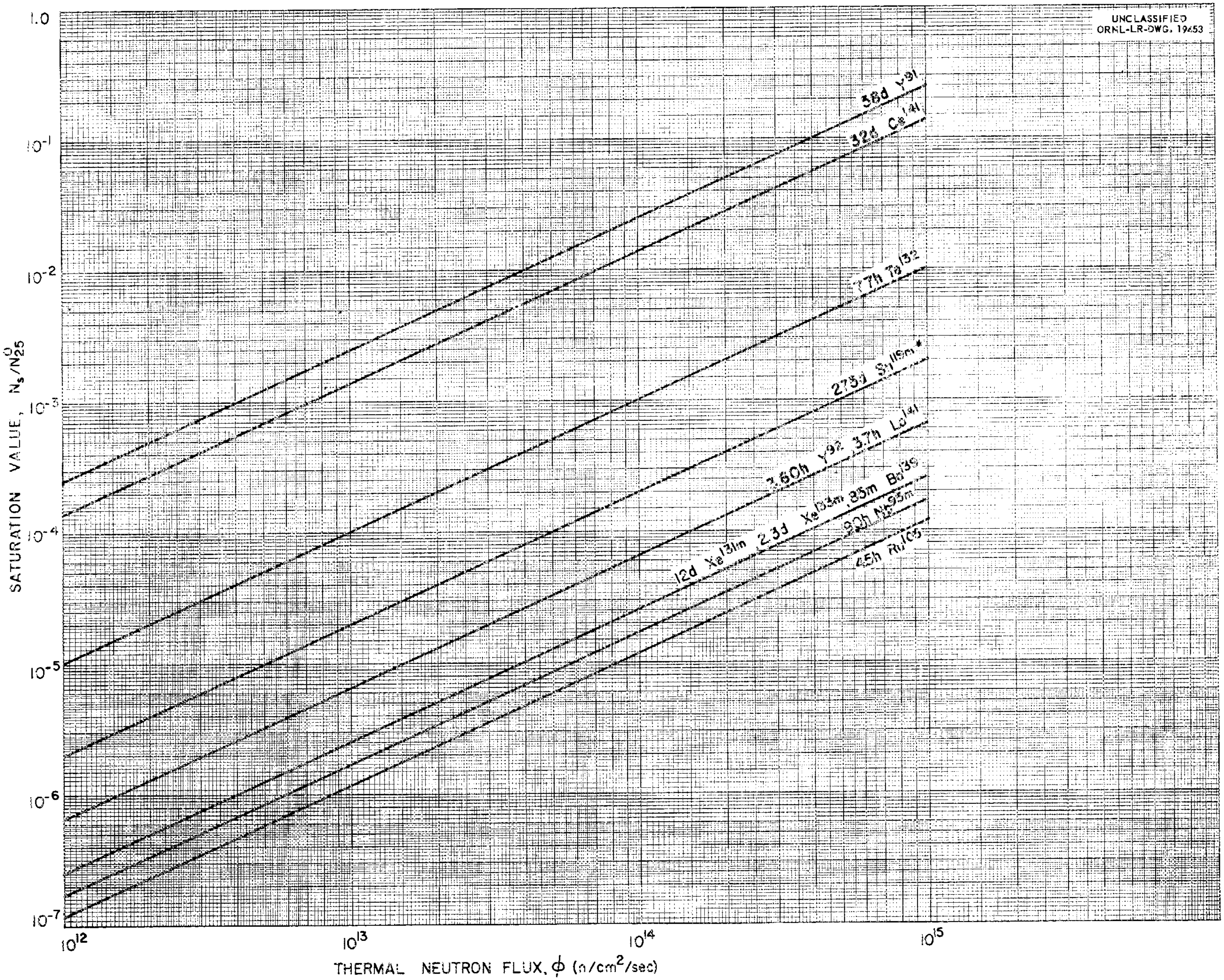

Fig. A-2c. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

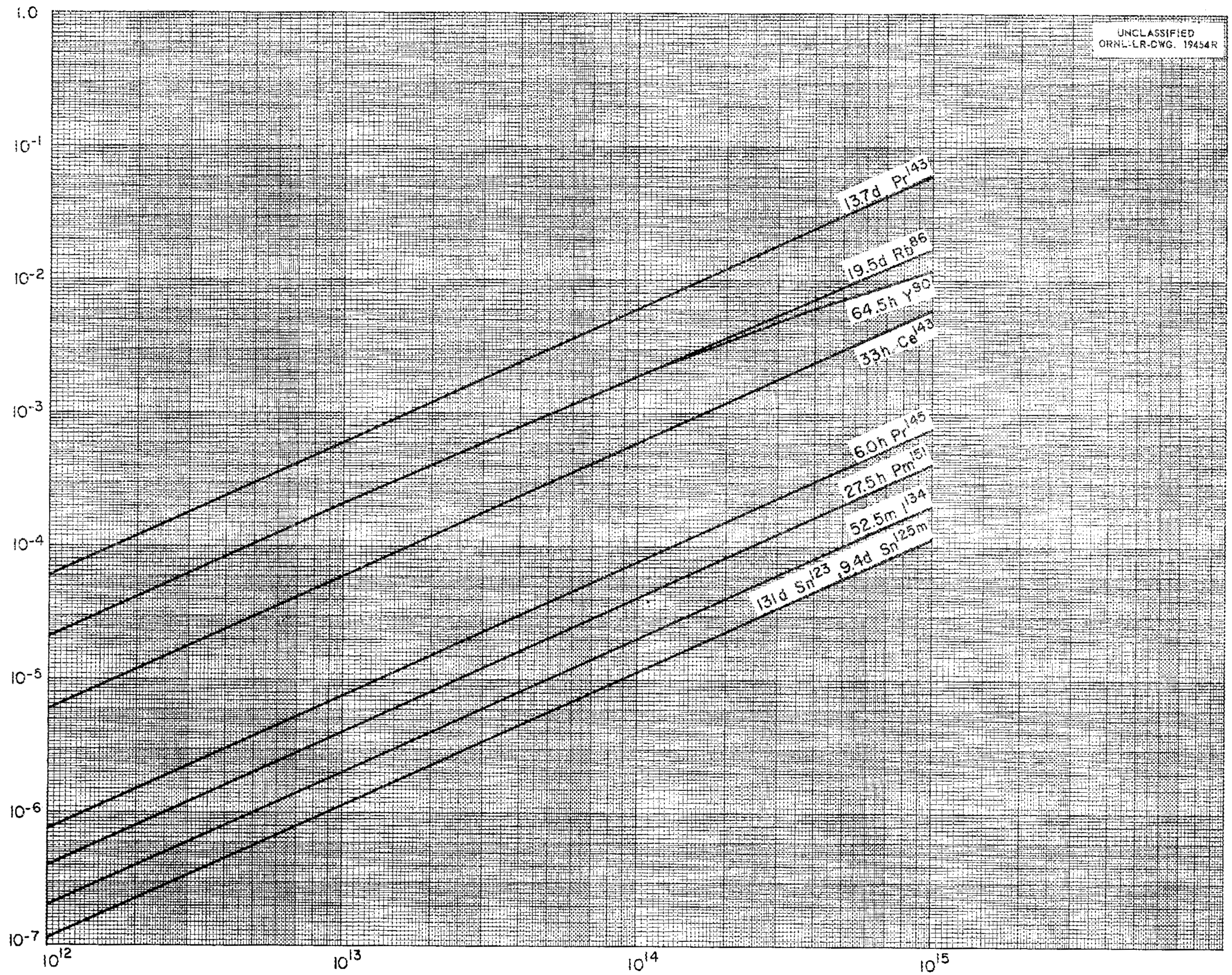

Fig. A-2d. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

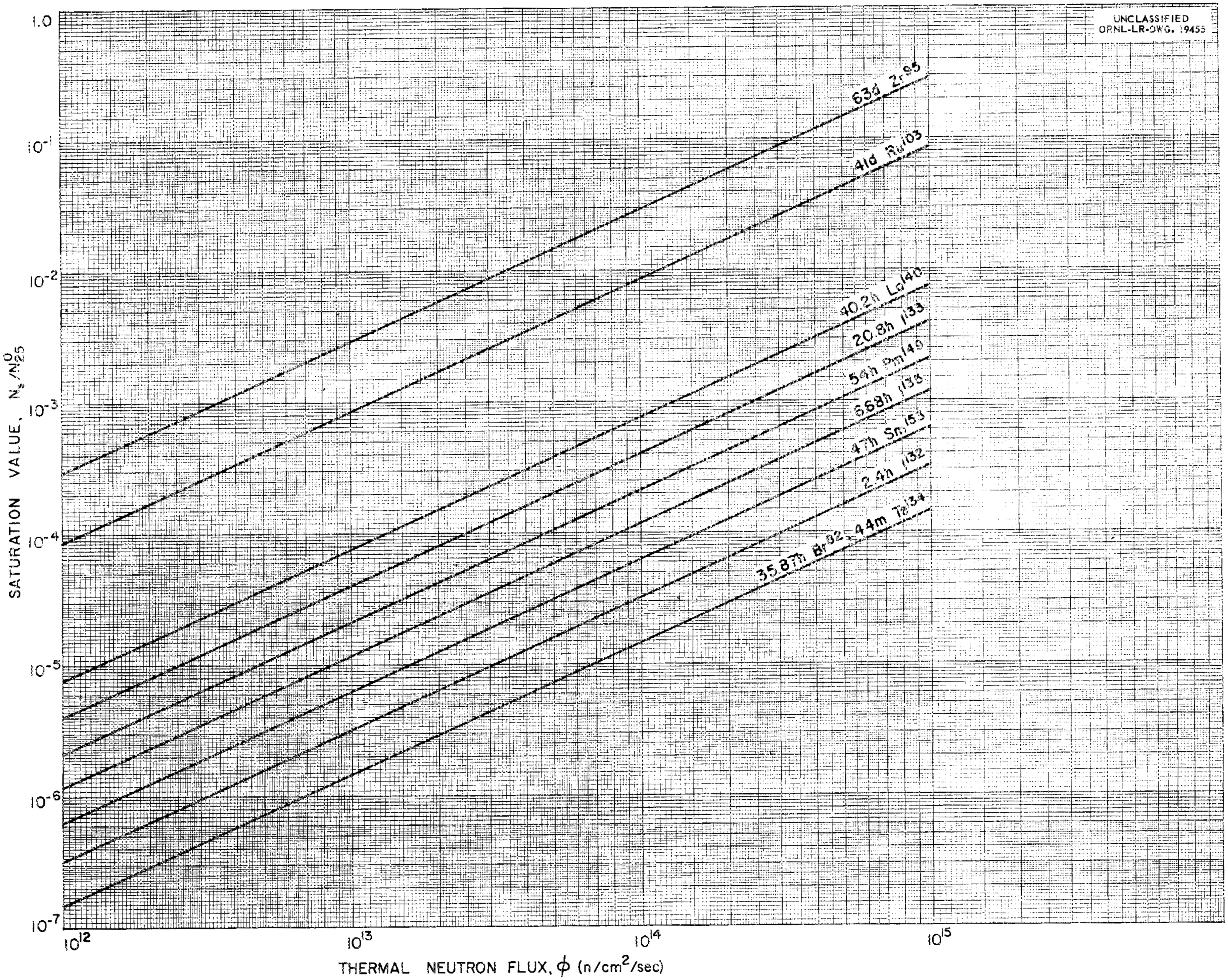

Fig. A-2e. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

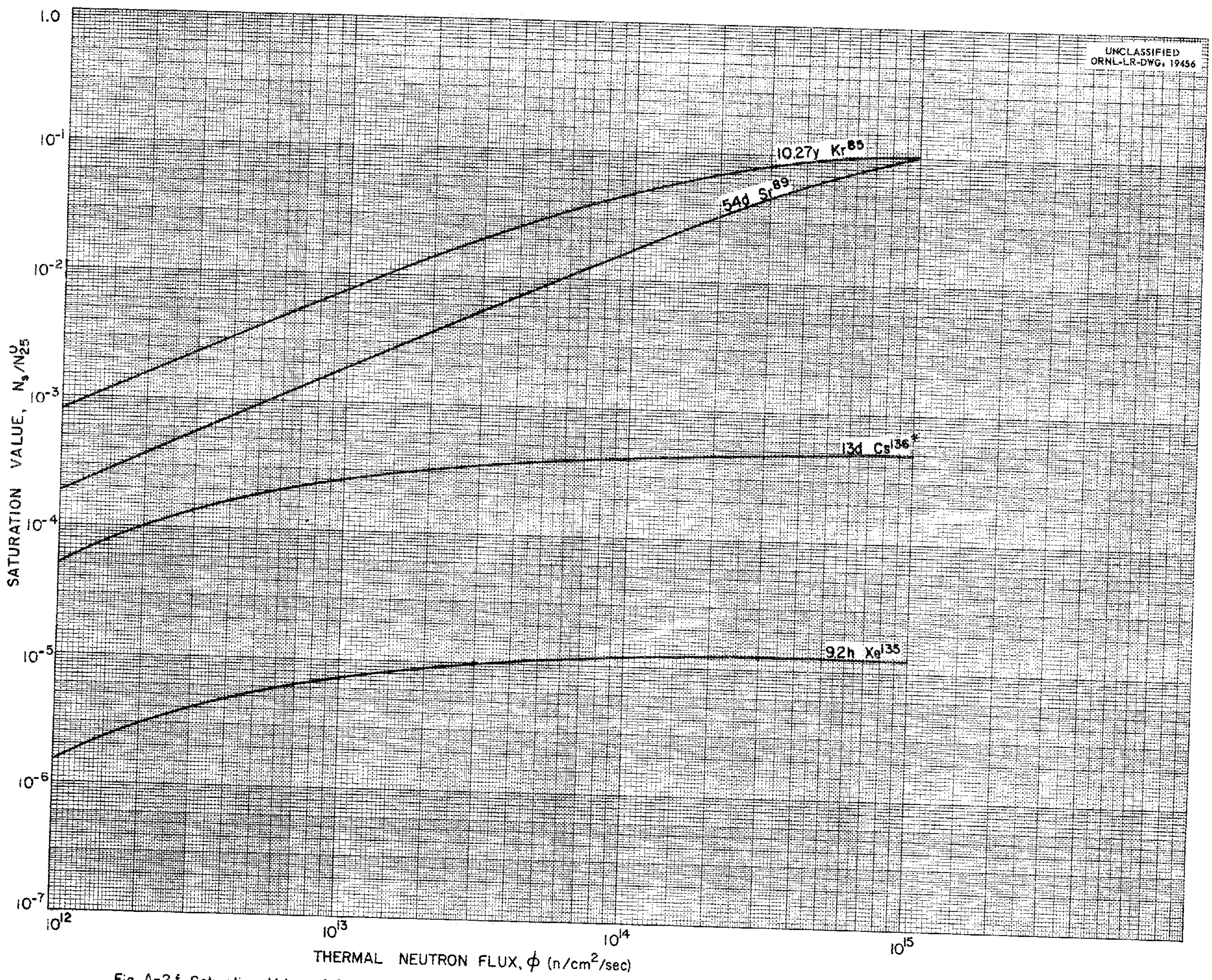

Fig. A-2 f. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

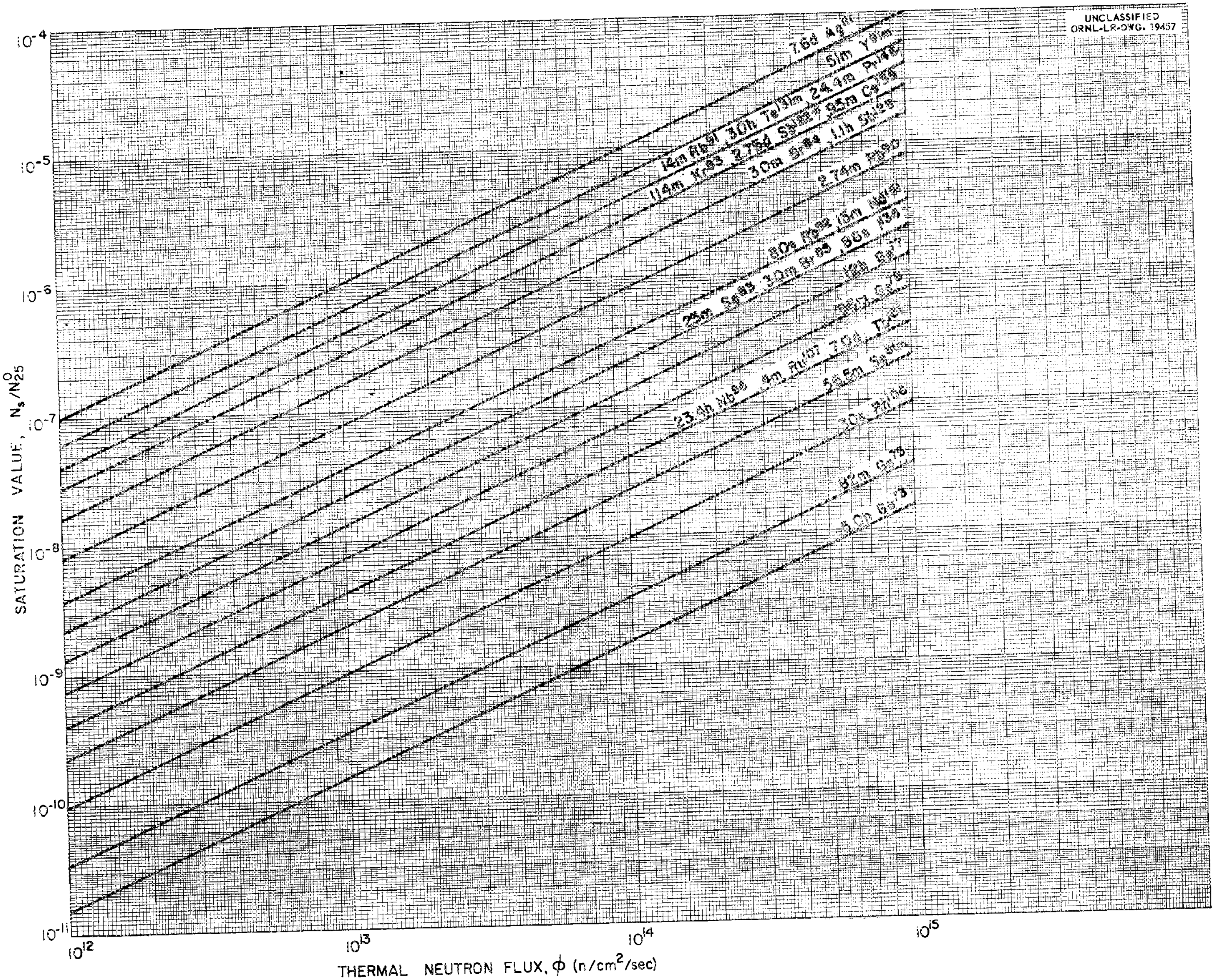

Fig. A-3. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

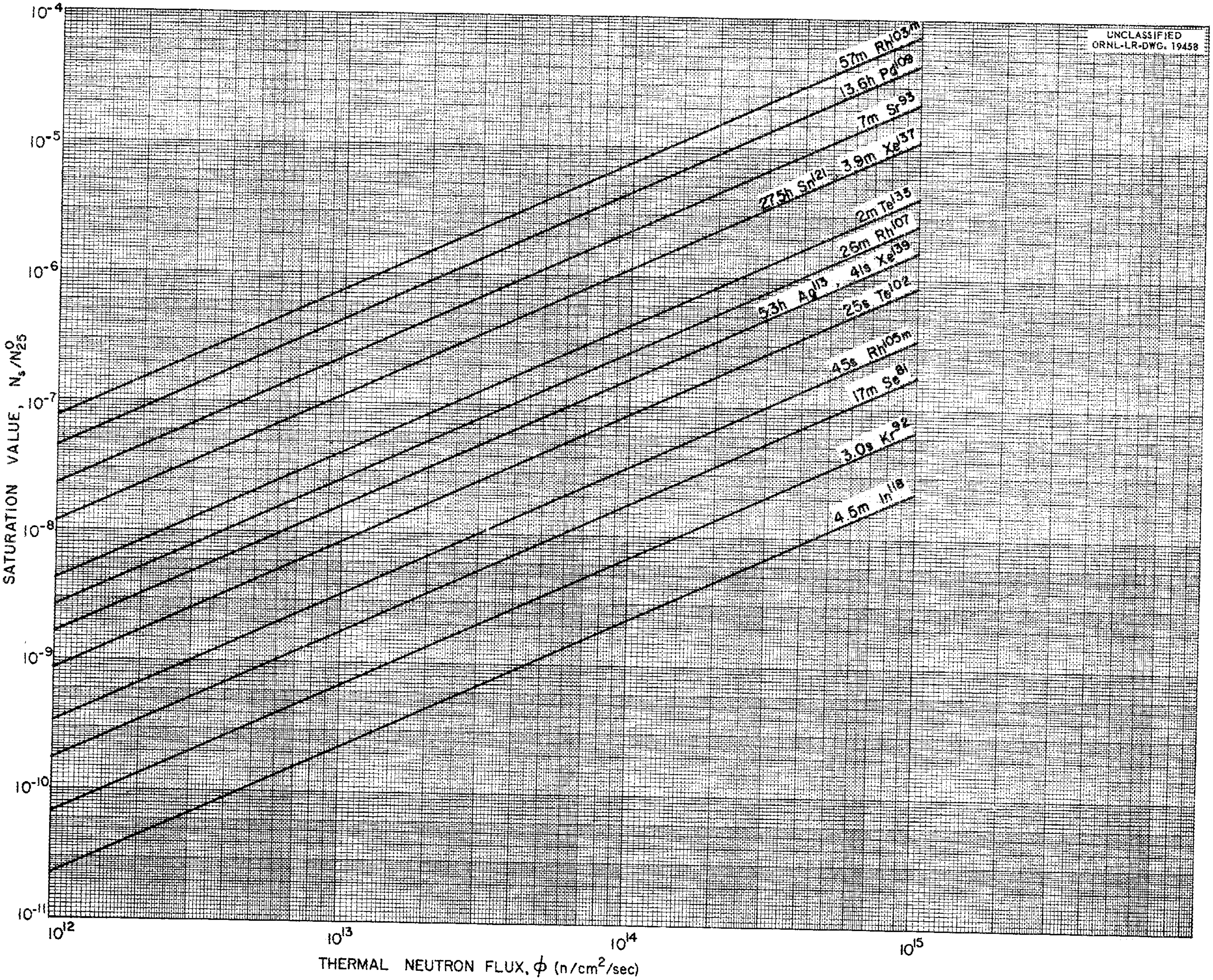

Fig. A-3a. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

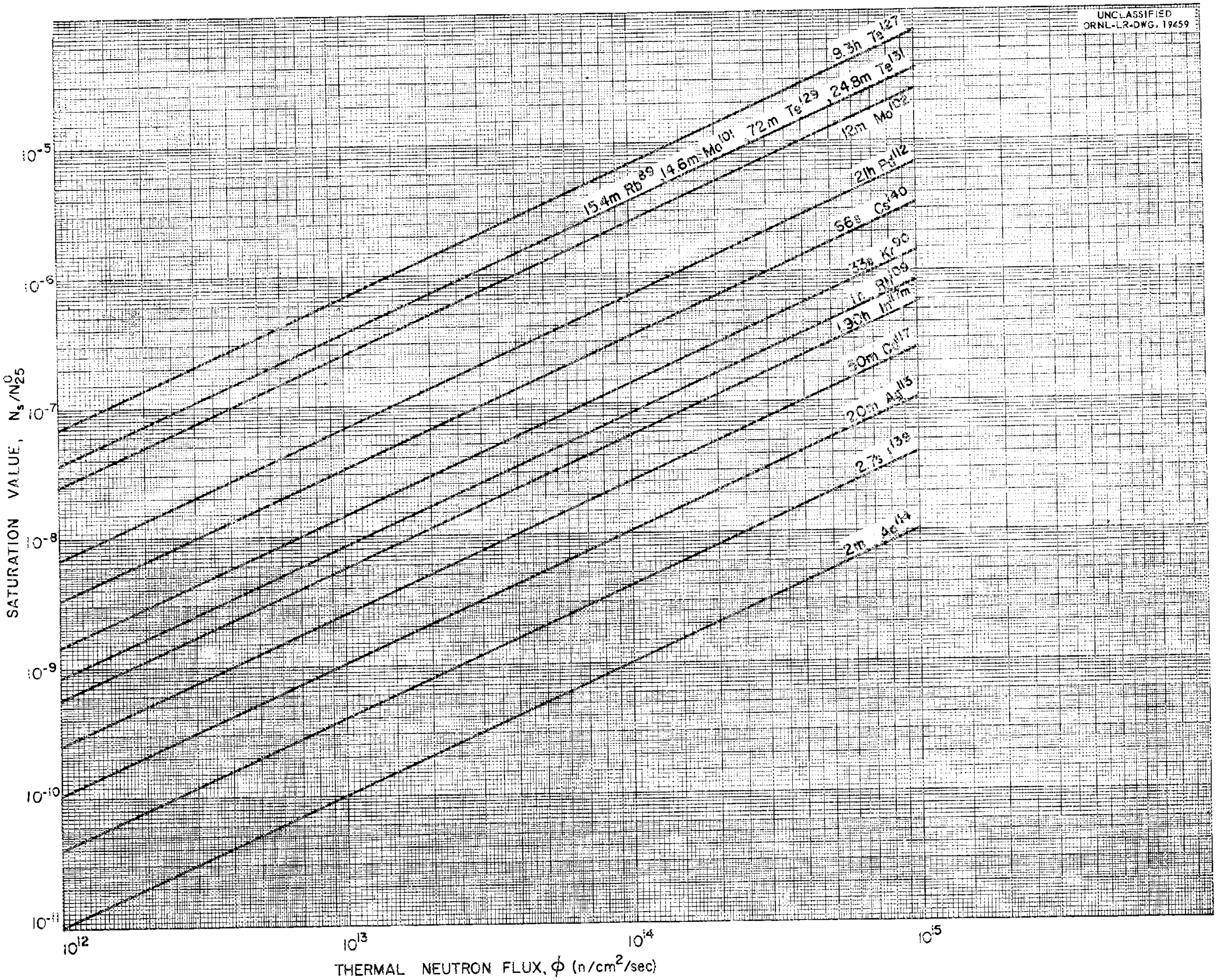

Fig. A-3b. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

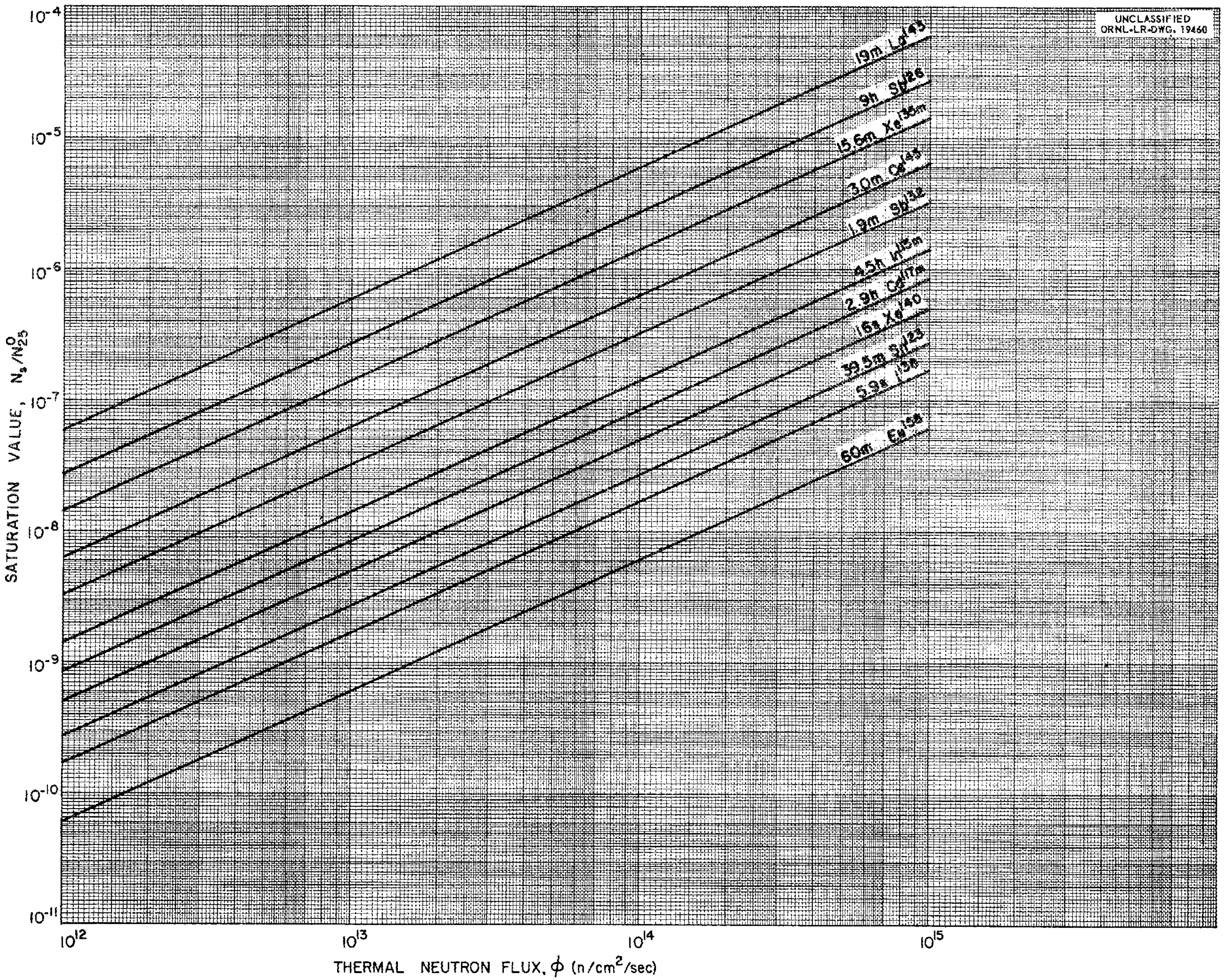

Fig. A-3c. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

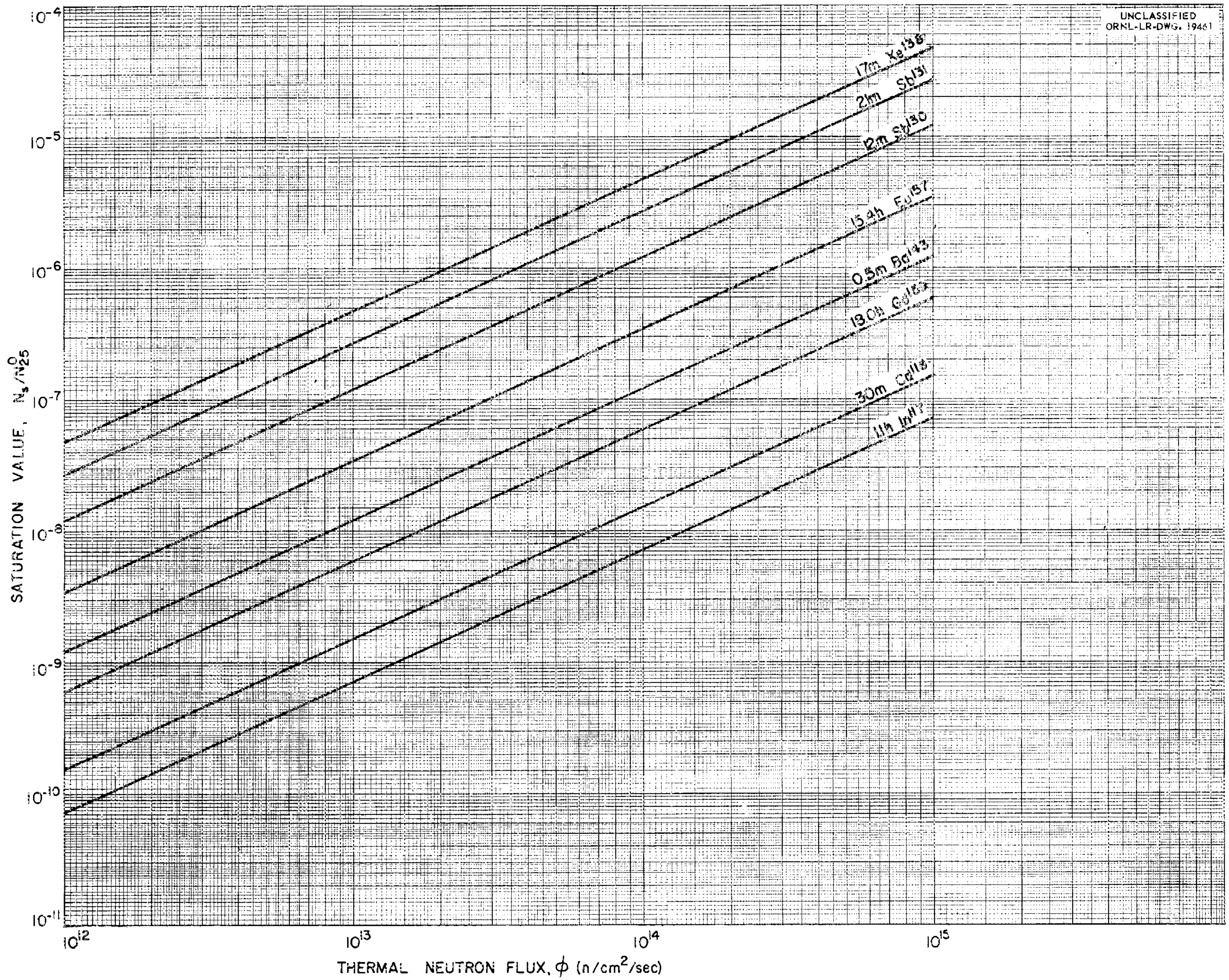

Fig. A-3d. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

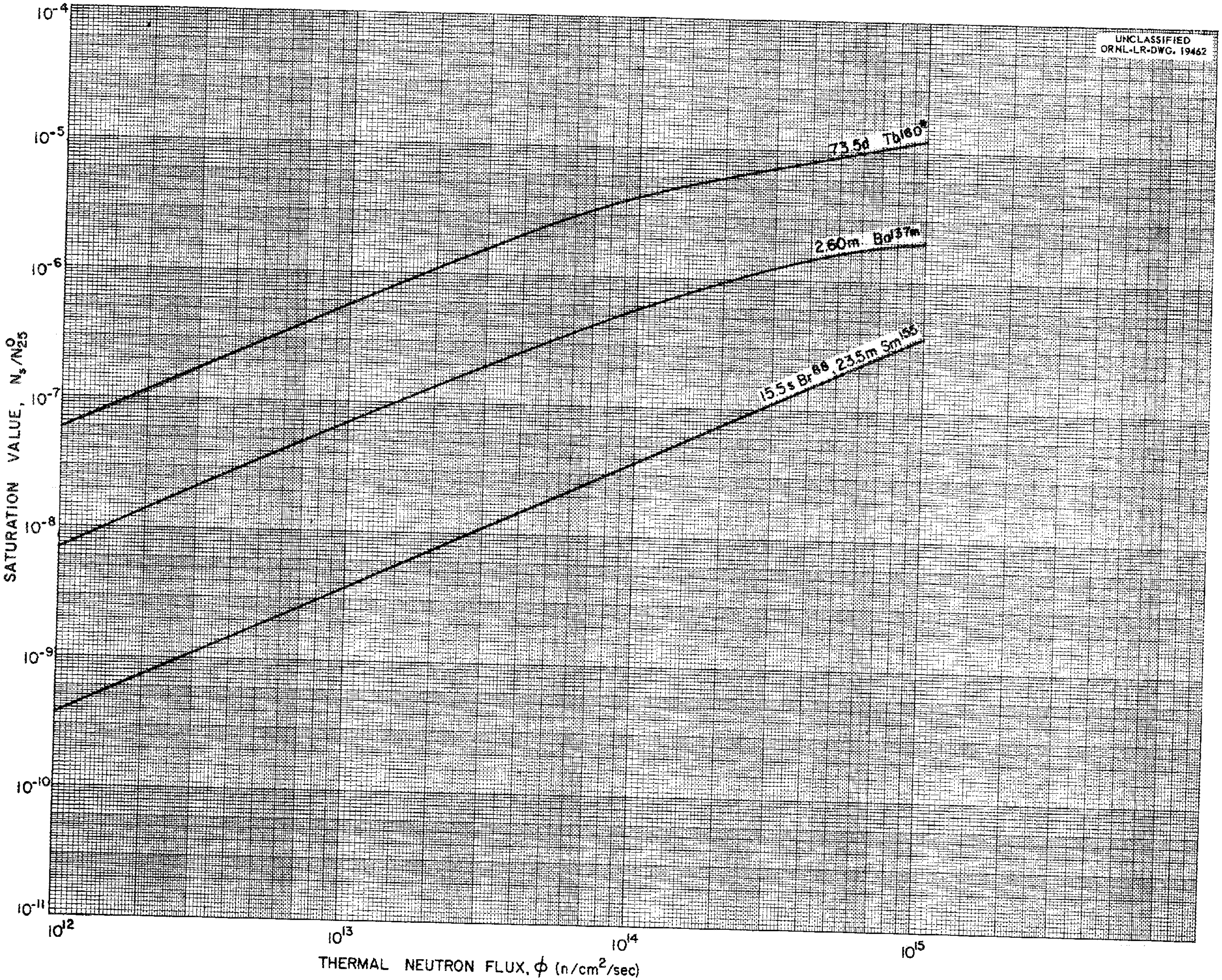

Fig. A-3e. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

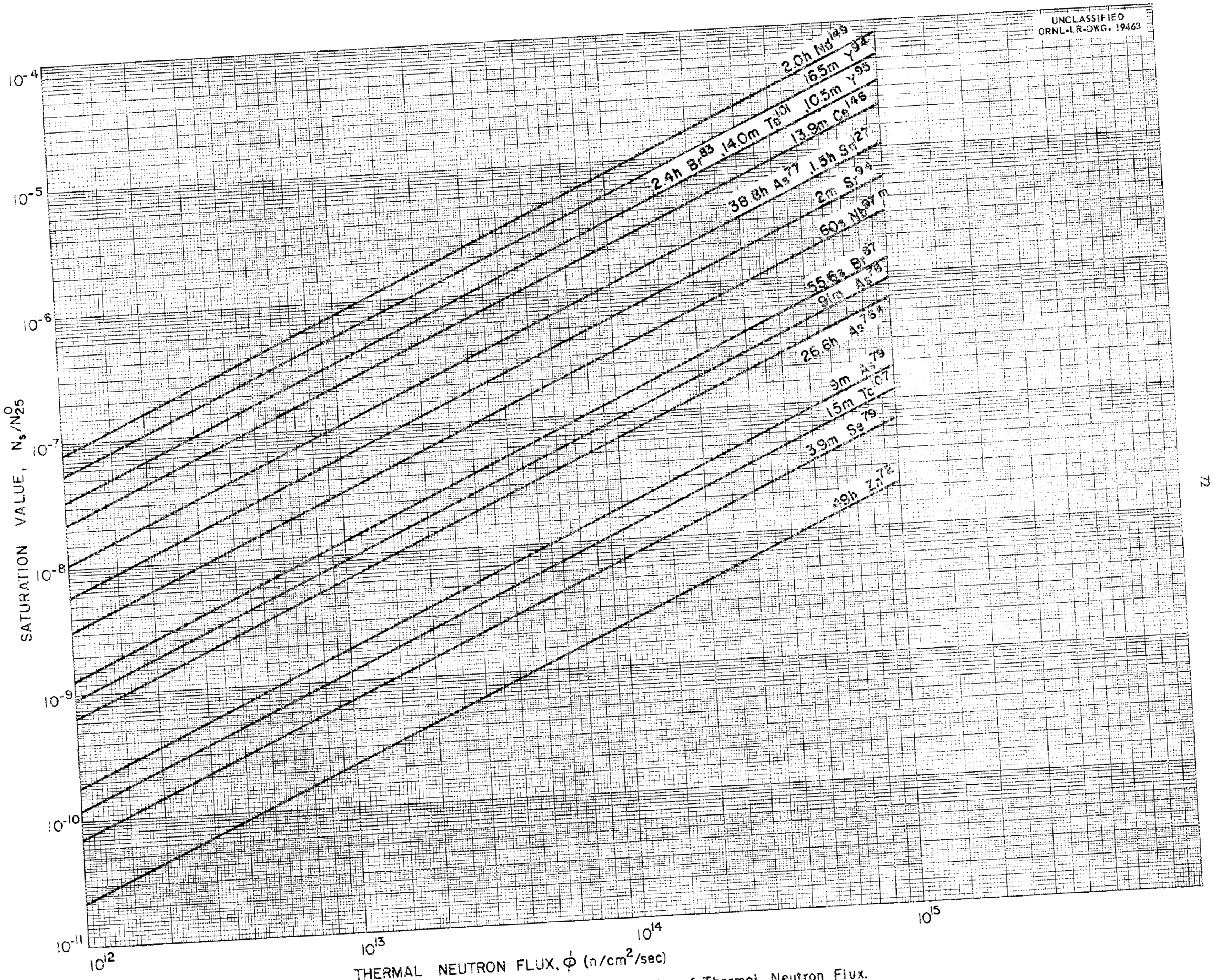

Fig. A-3f. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

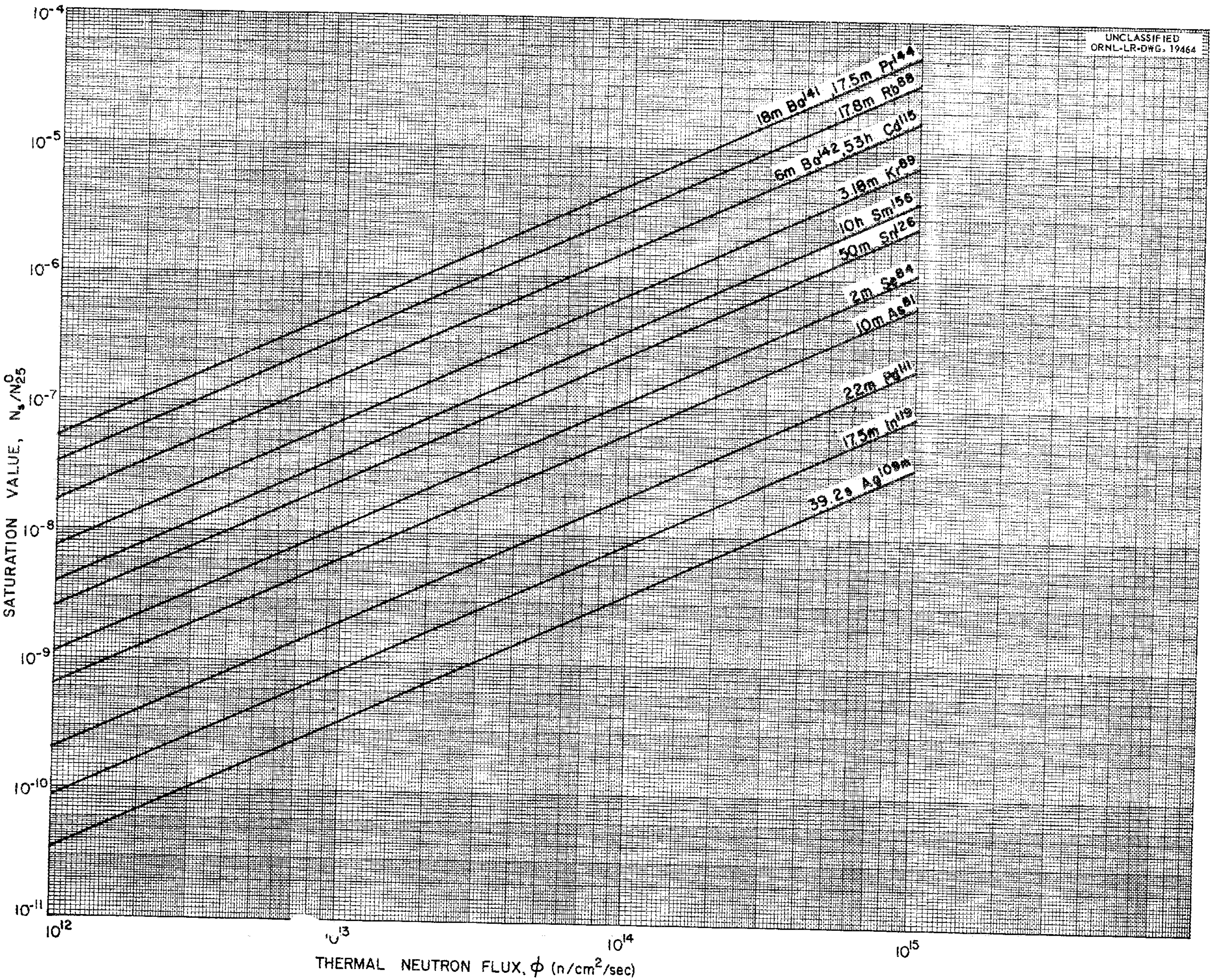

Fig. A-3g. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

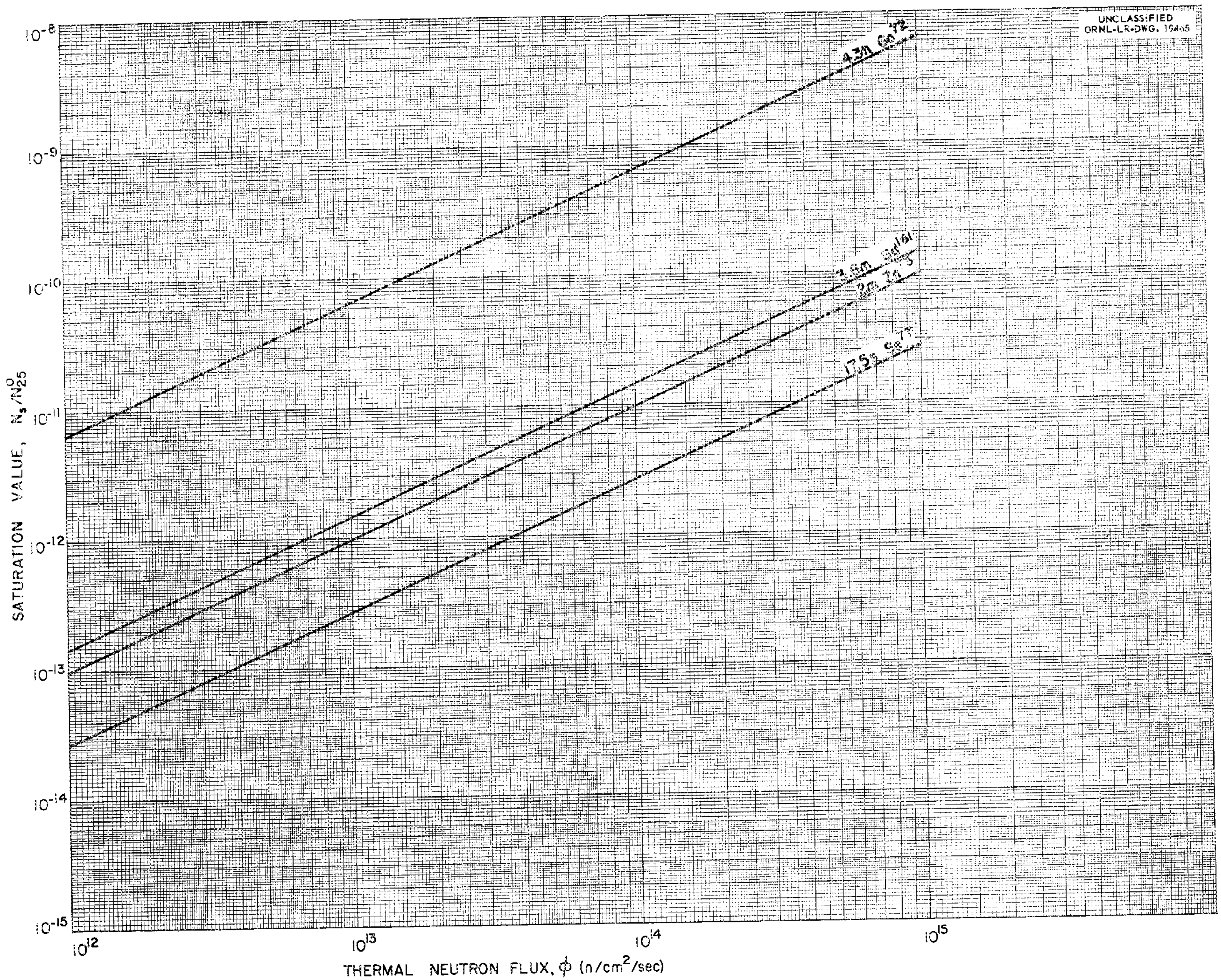

Fig. A-4. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

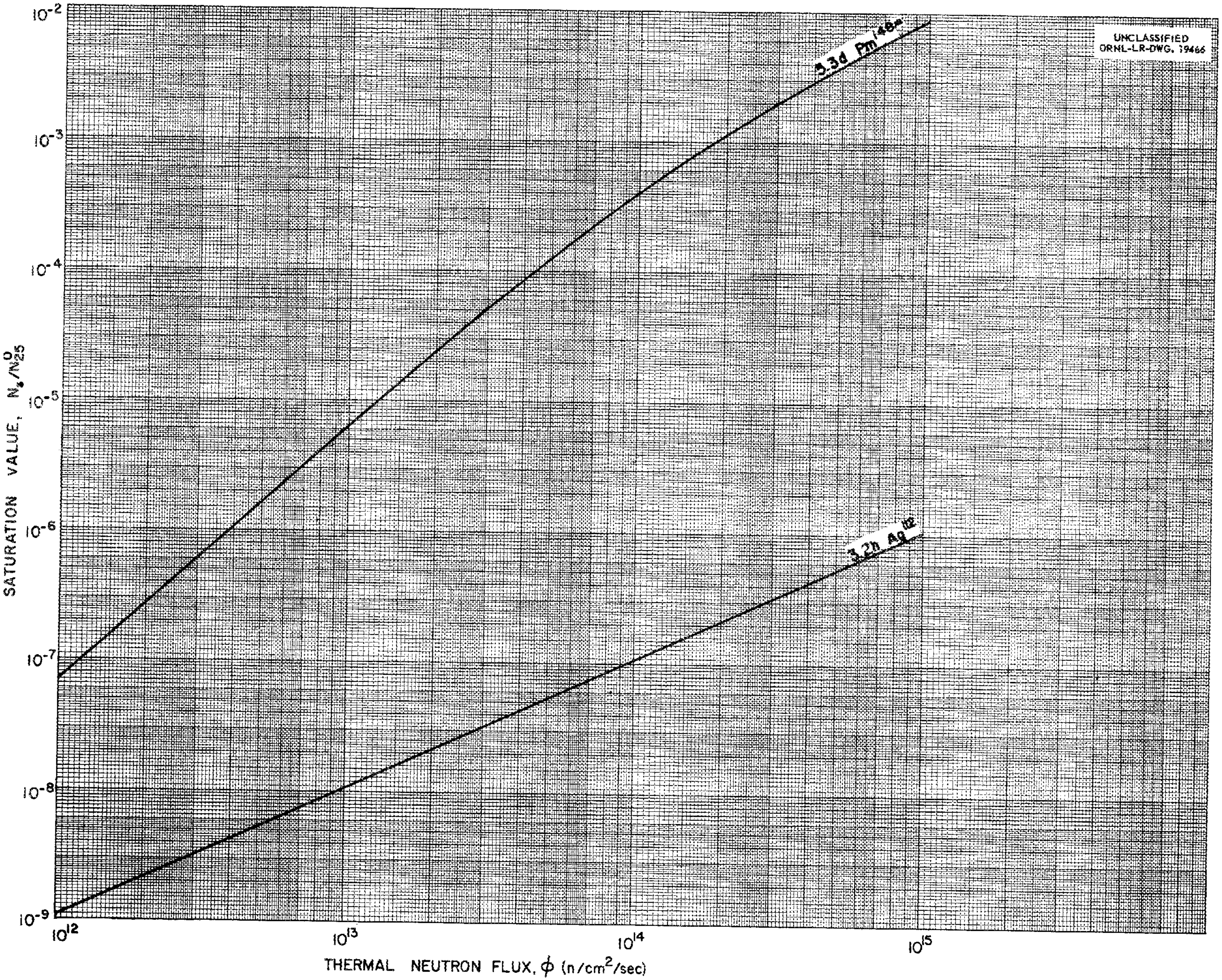

Fig. A-4a. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

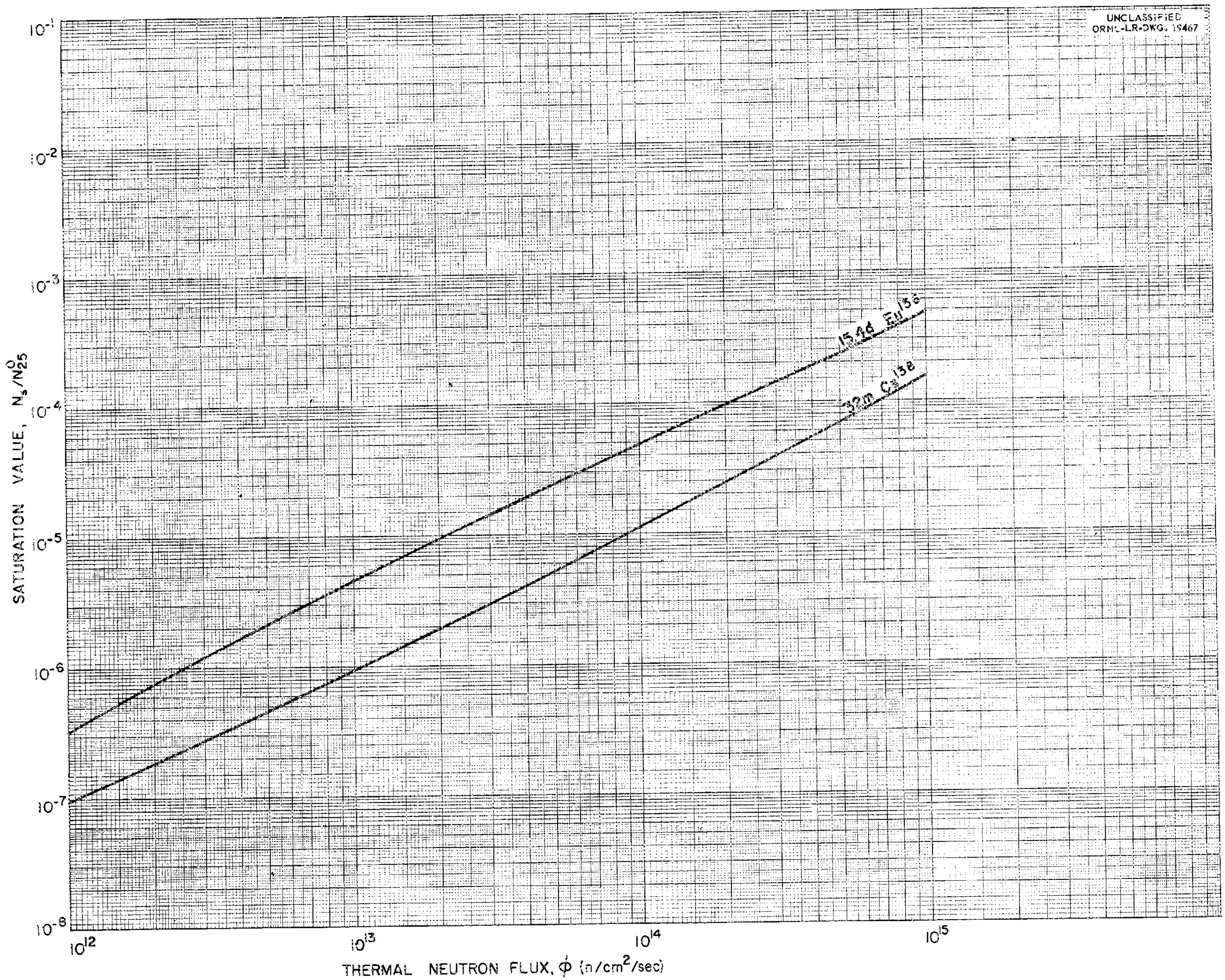

Fig. A-4b. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

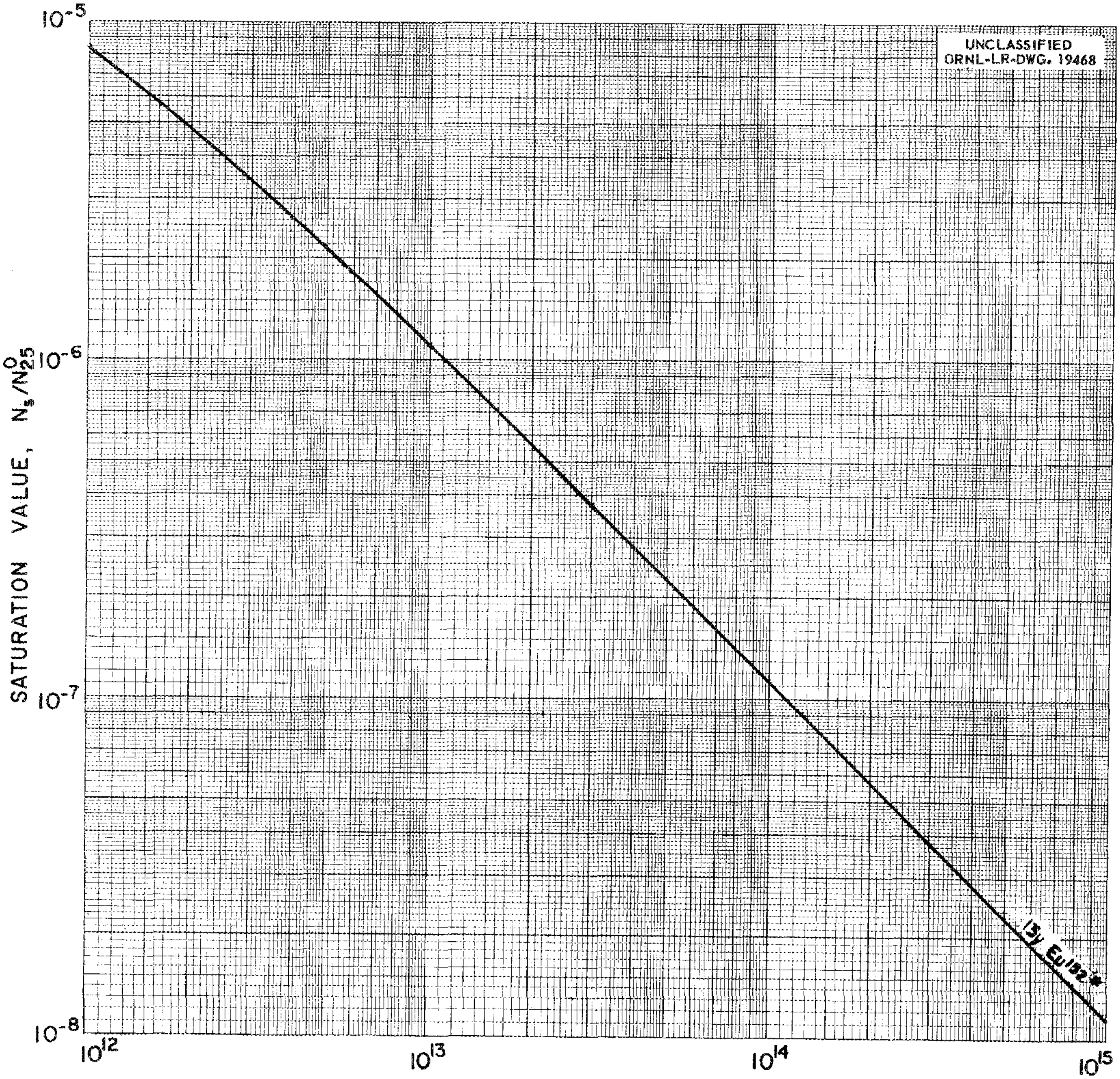

Fig. A-4 c. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

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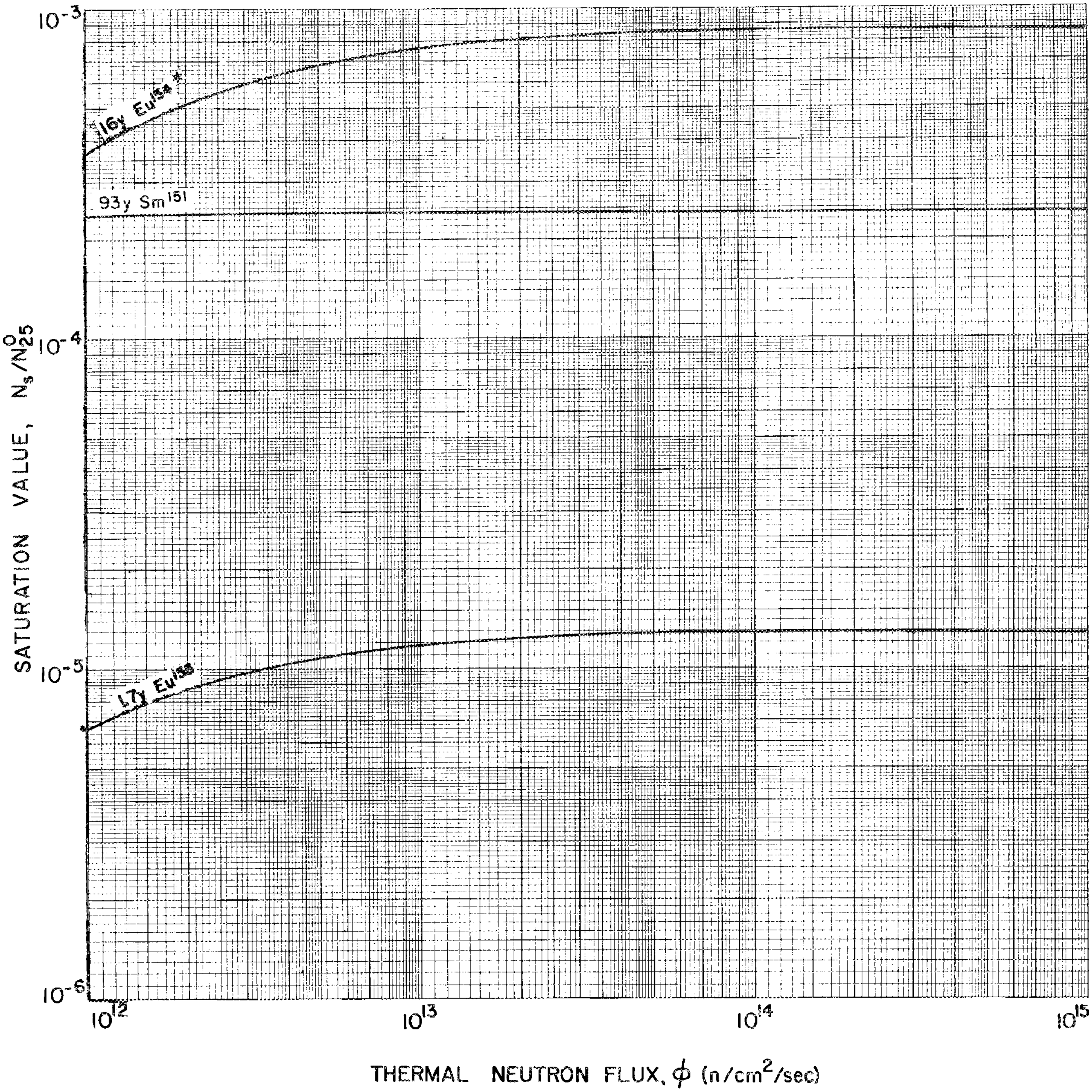

Fig. A-4d. Saturation Value of Radioactive Fission Products as a Function of Thermal Neutron Flux.

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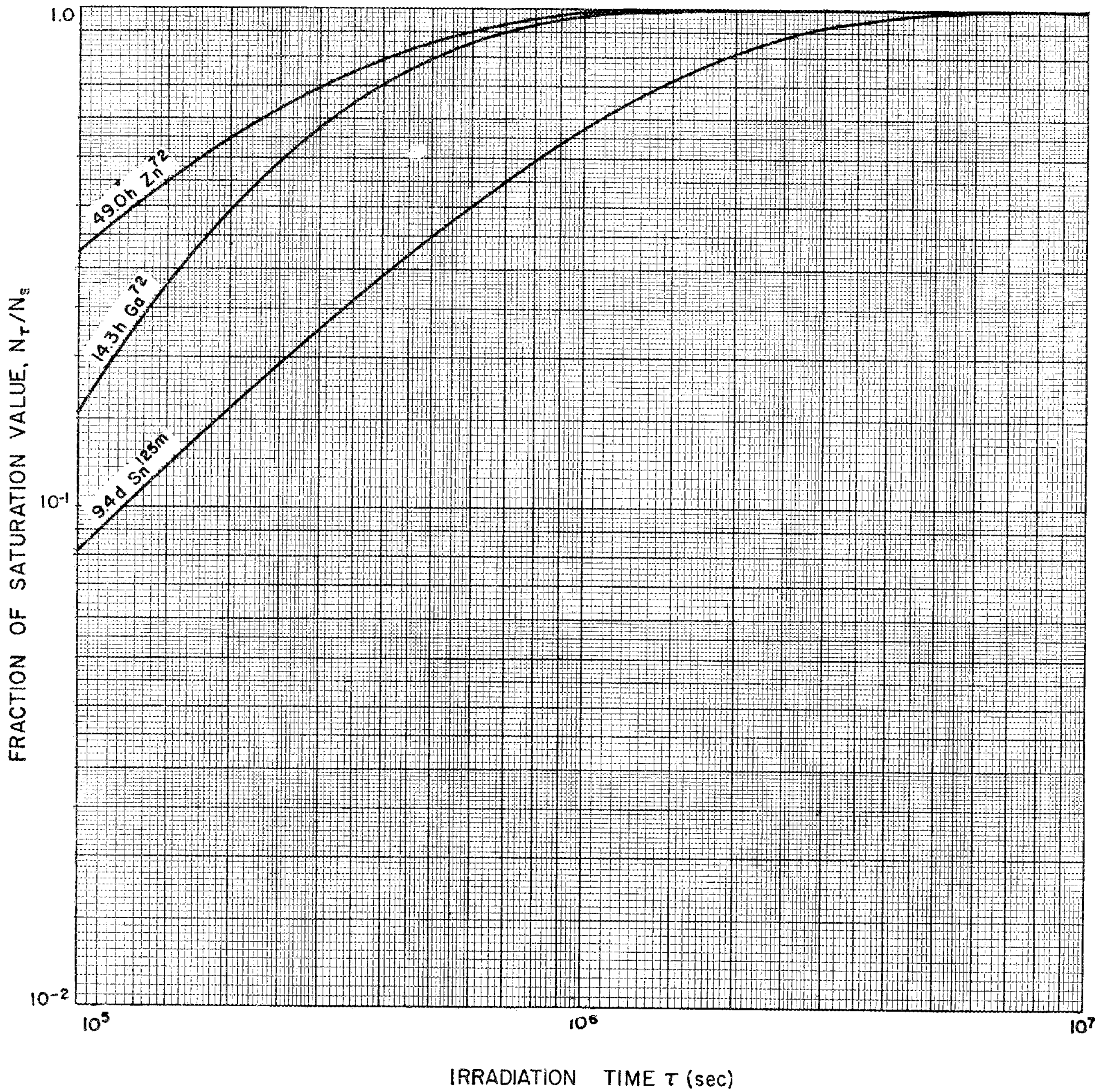

Fig. B-1. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

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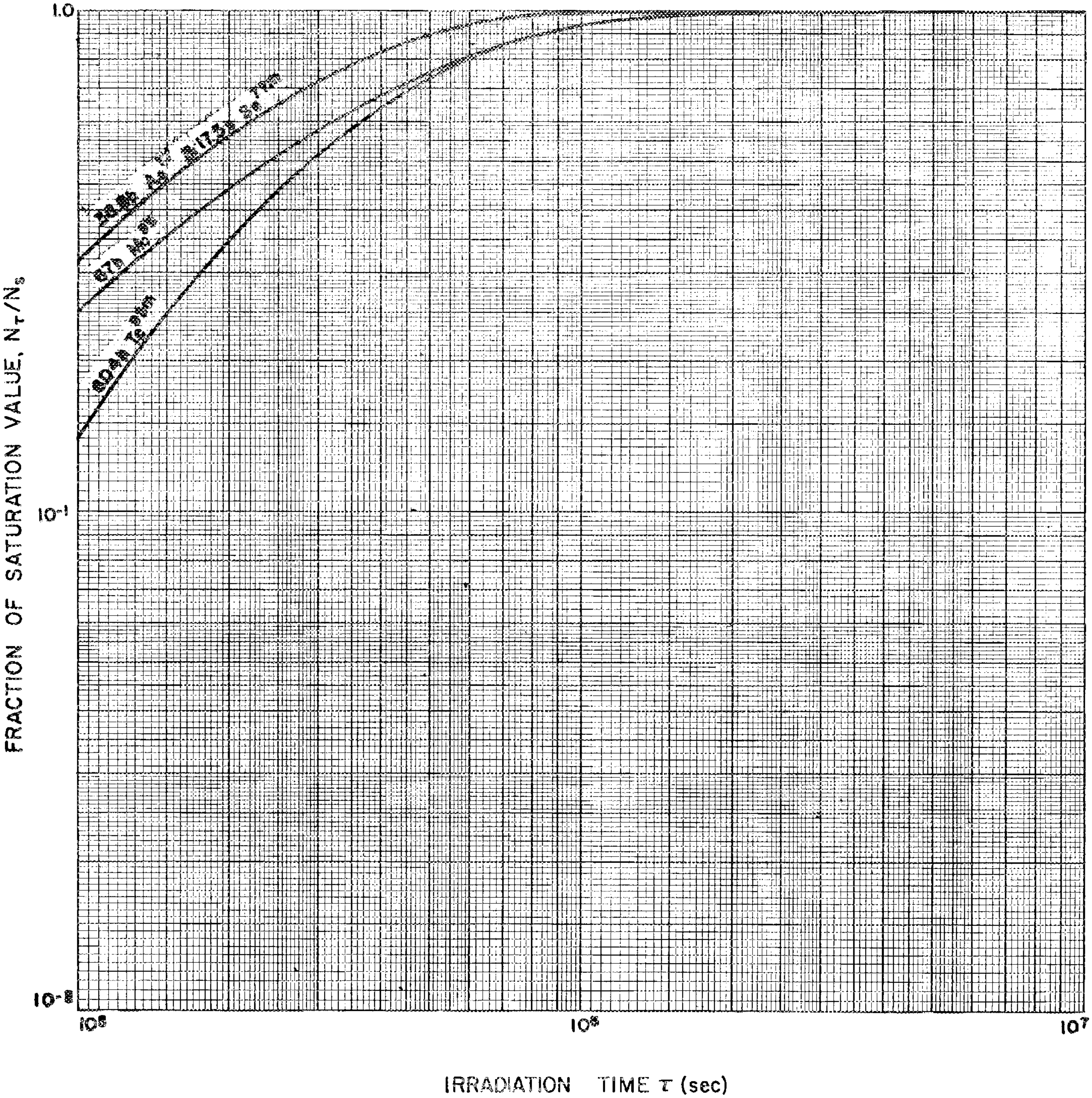

Fig. 8-2. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

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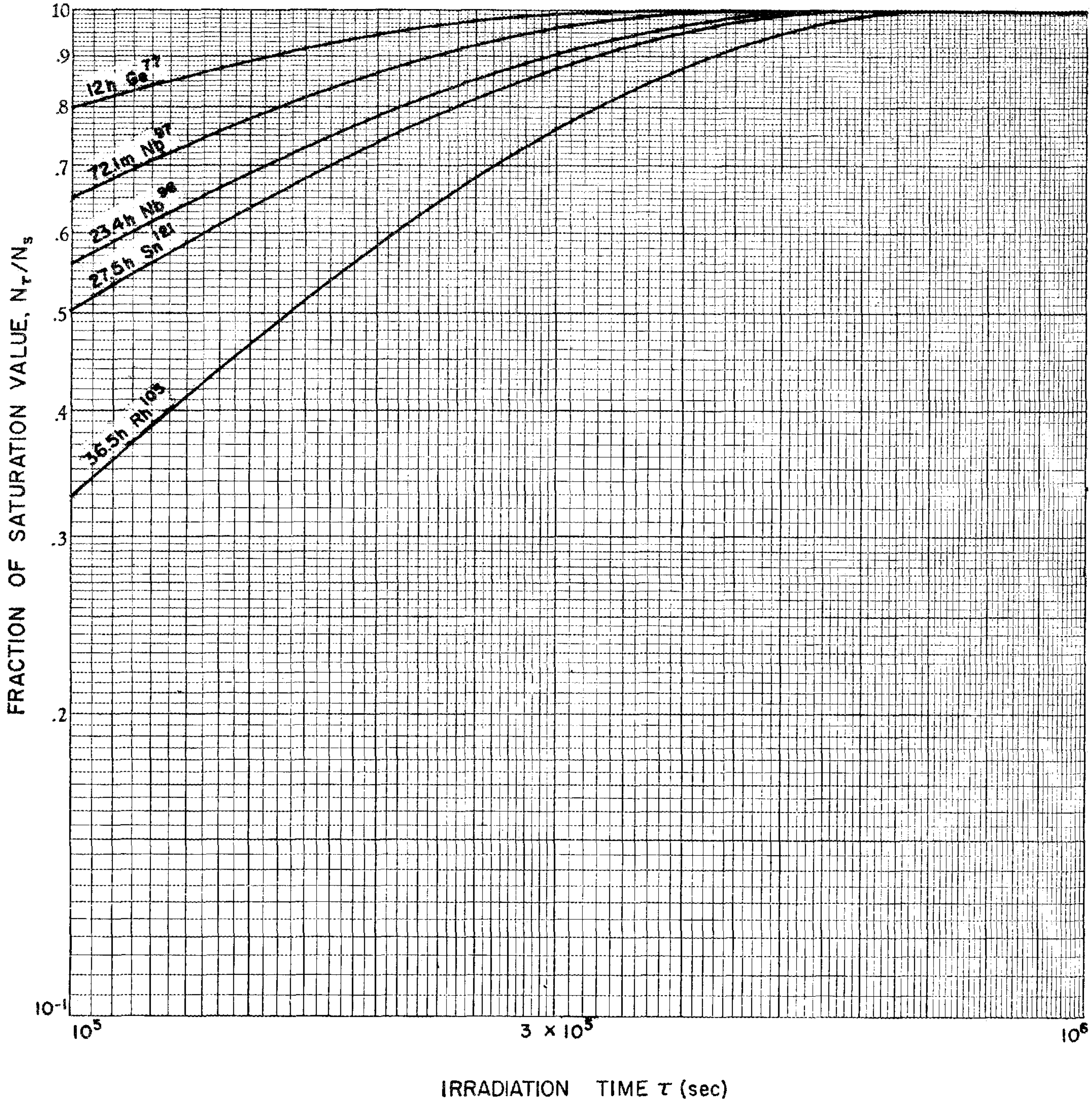

Fig. B-3. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

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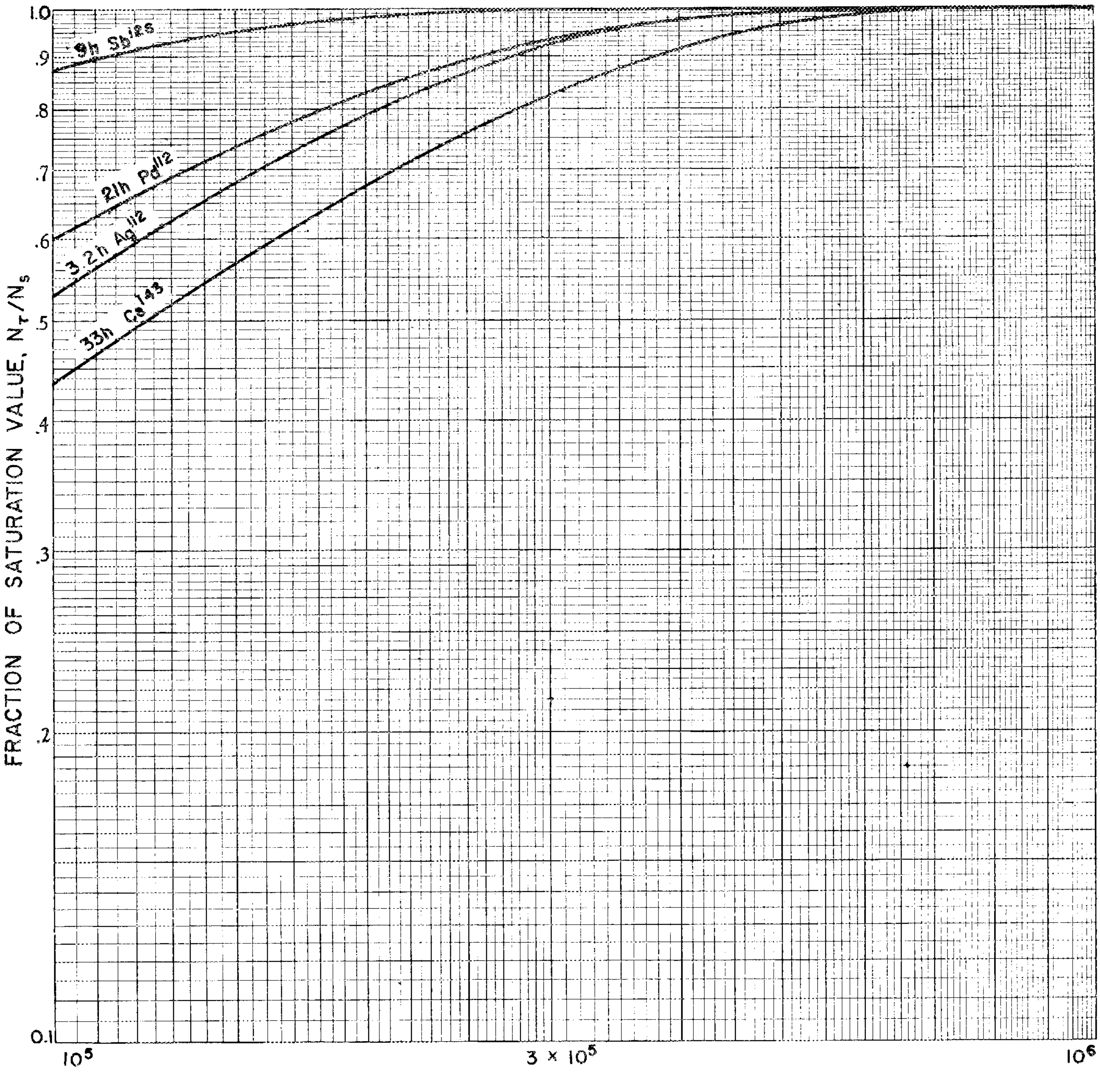

Fig. B-4. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

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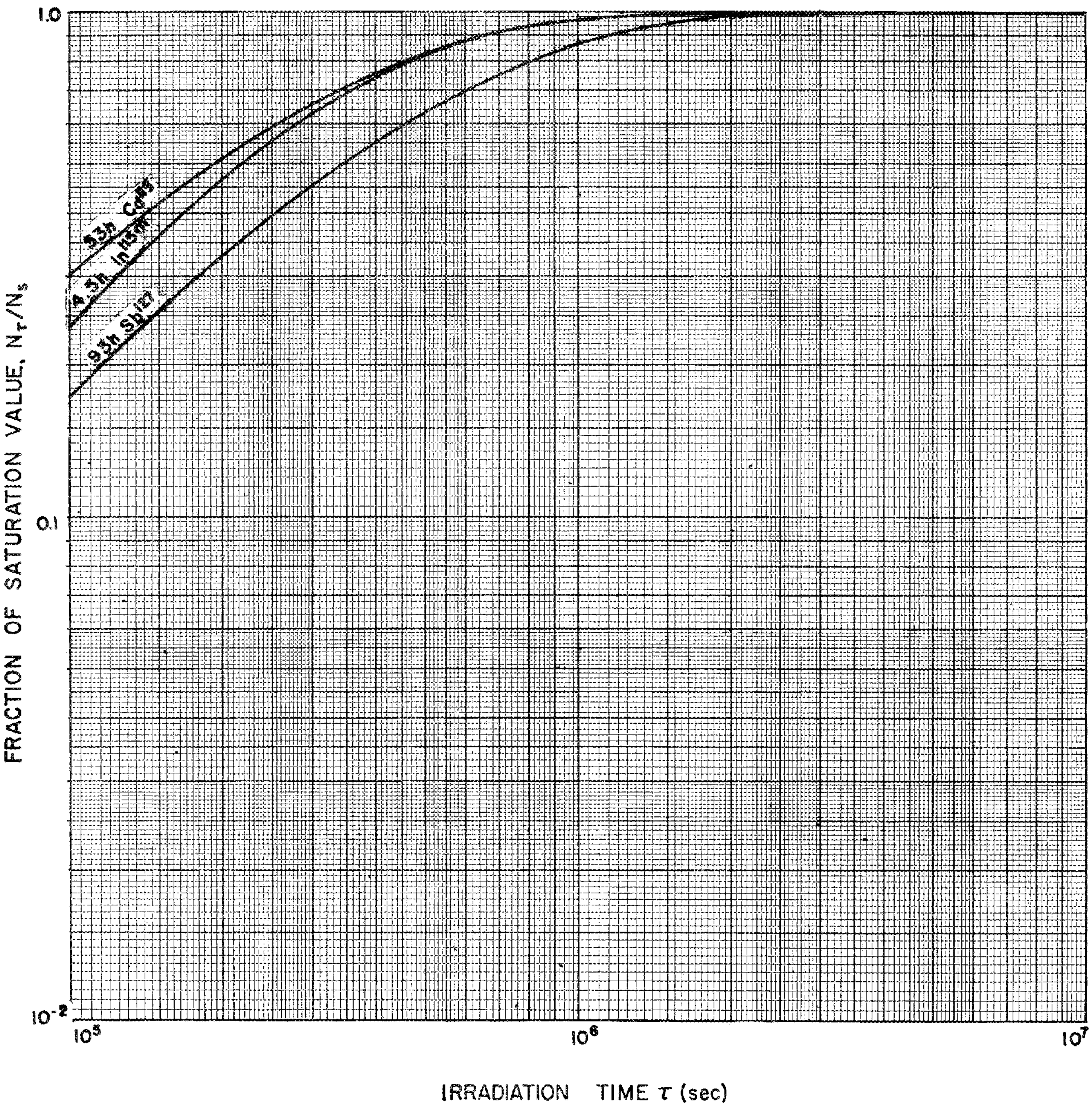

Fig. B-5. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

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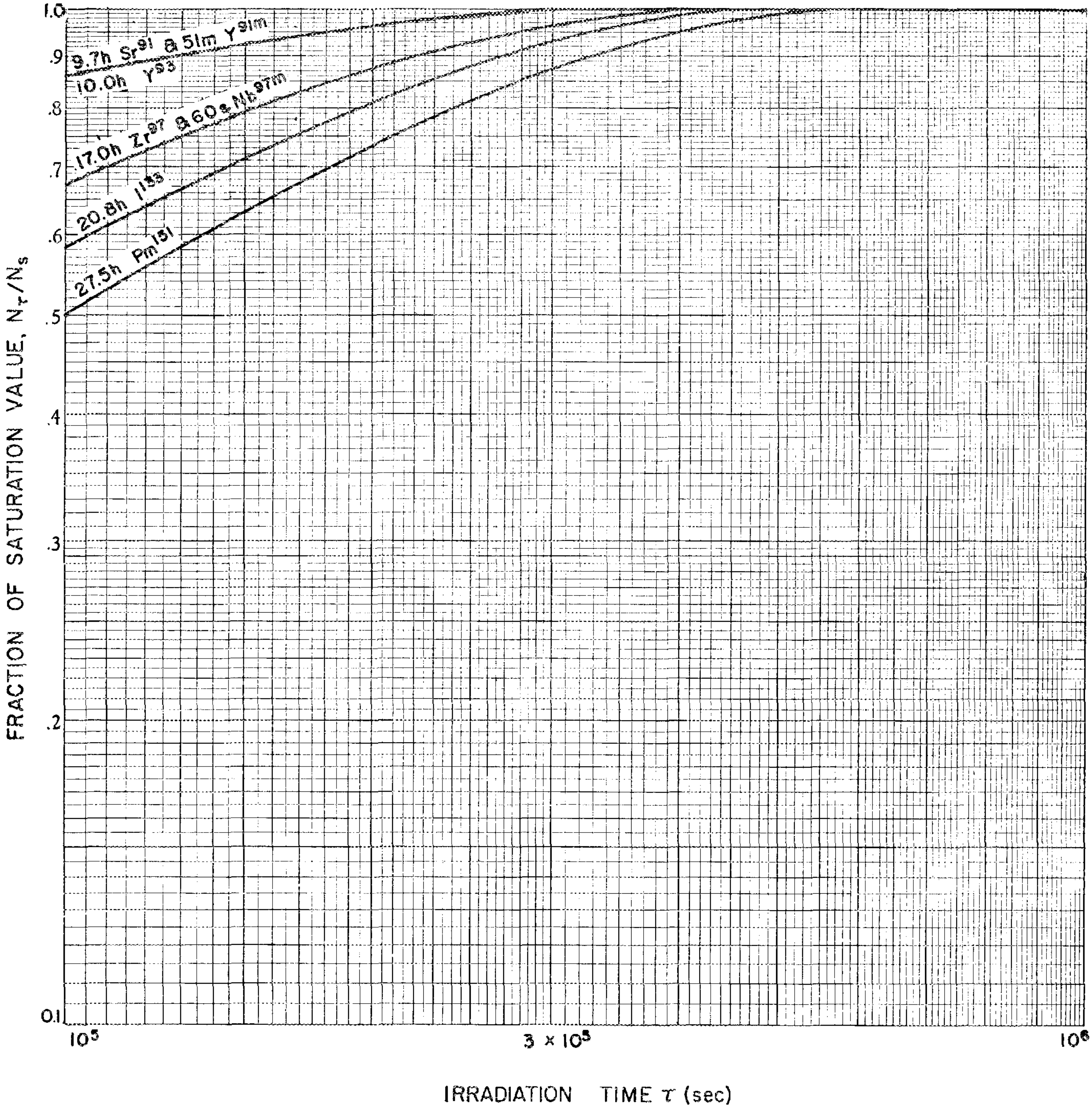

Fig. B-6. Fraction of Saturation Value of Various Radioactive Fissión Products as a Function of Irradiation Time.

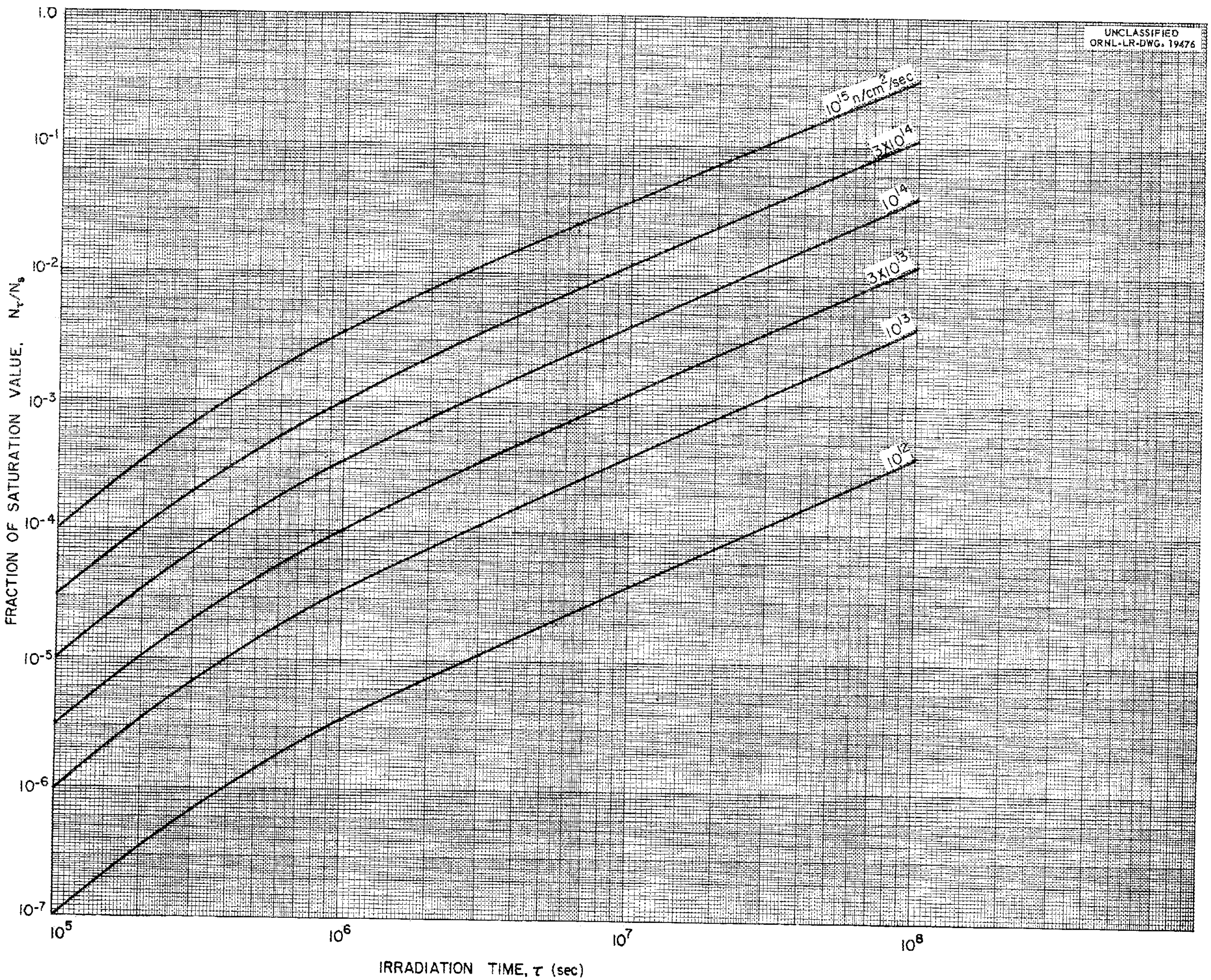

Fig. B-7. Fraction of Saturation Value of 26.6h As^{76*} as a Function of Irradiation Time and Flux.

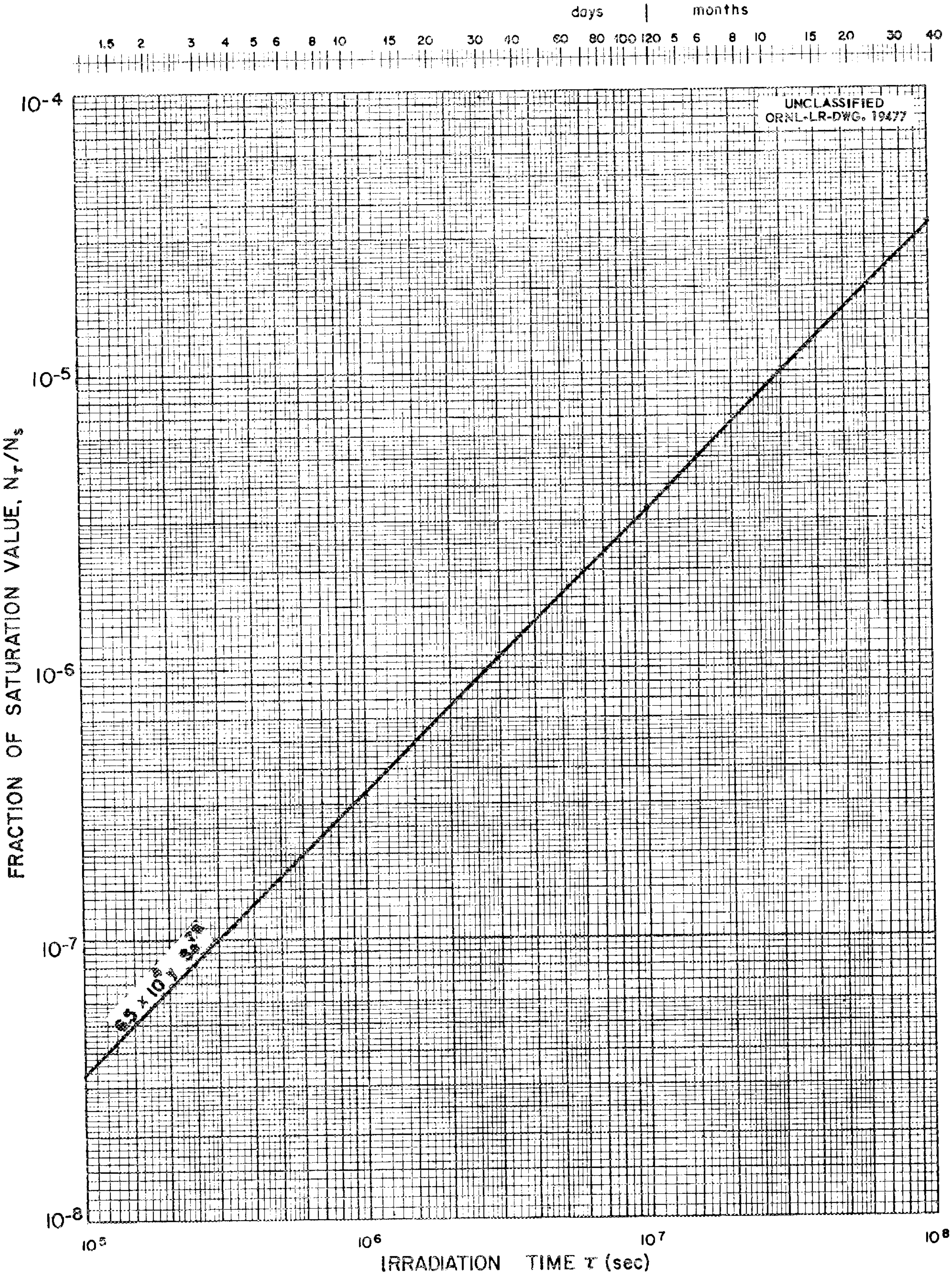

Fig. B-8. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

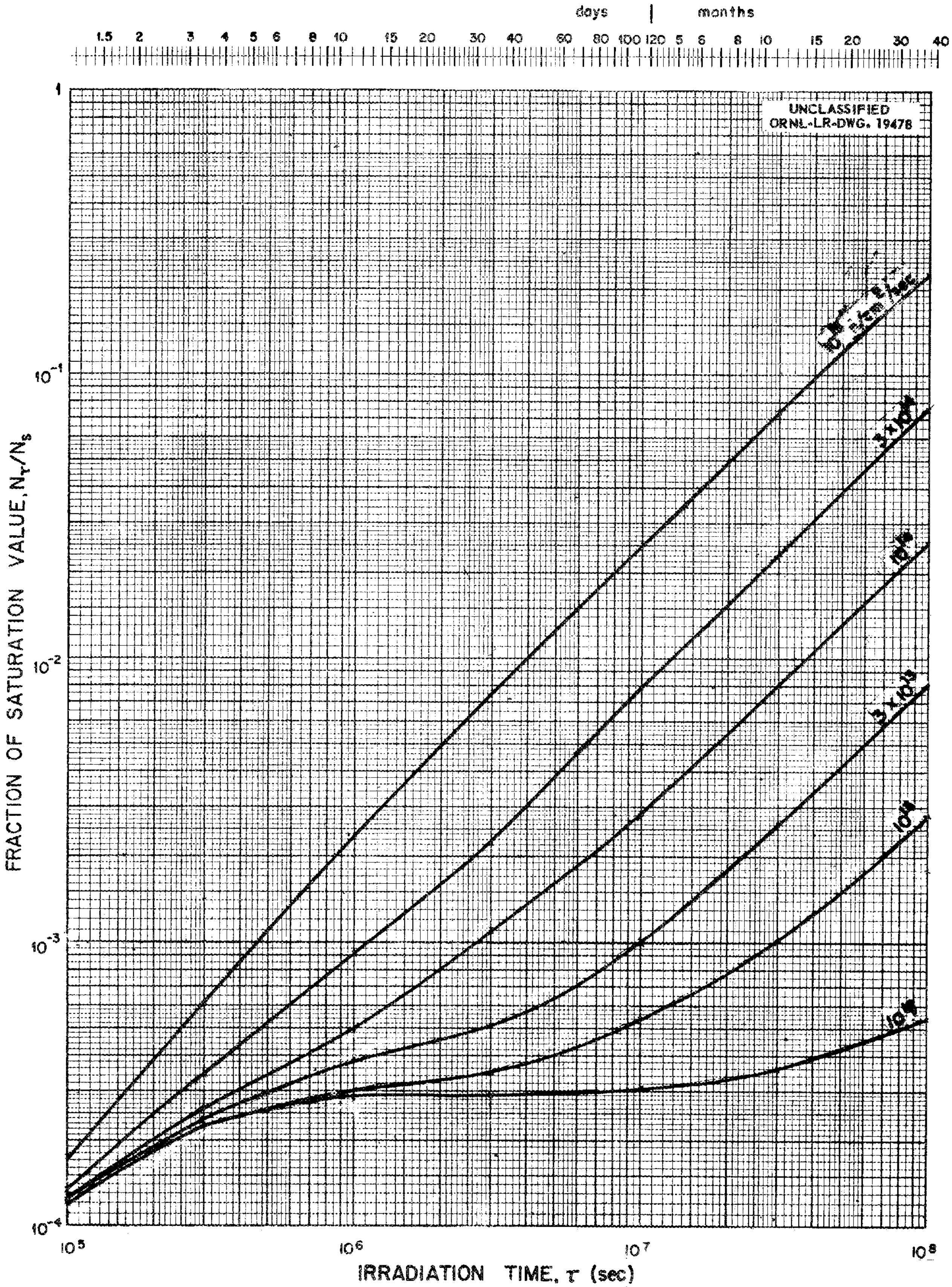

Fig. B-9. Fraction of Saturation Value of 35.87h Br^{82} as a Function of Irradiation Time and Flux.

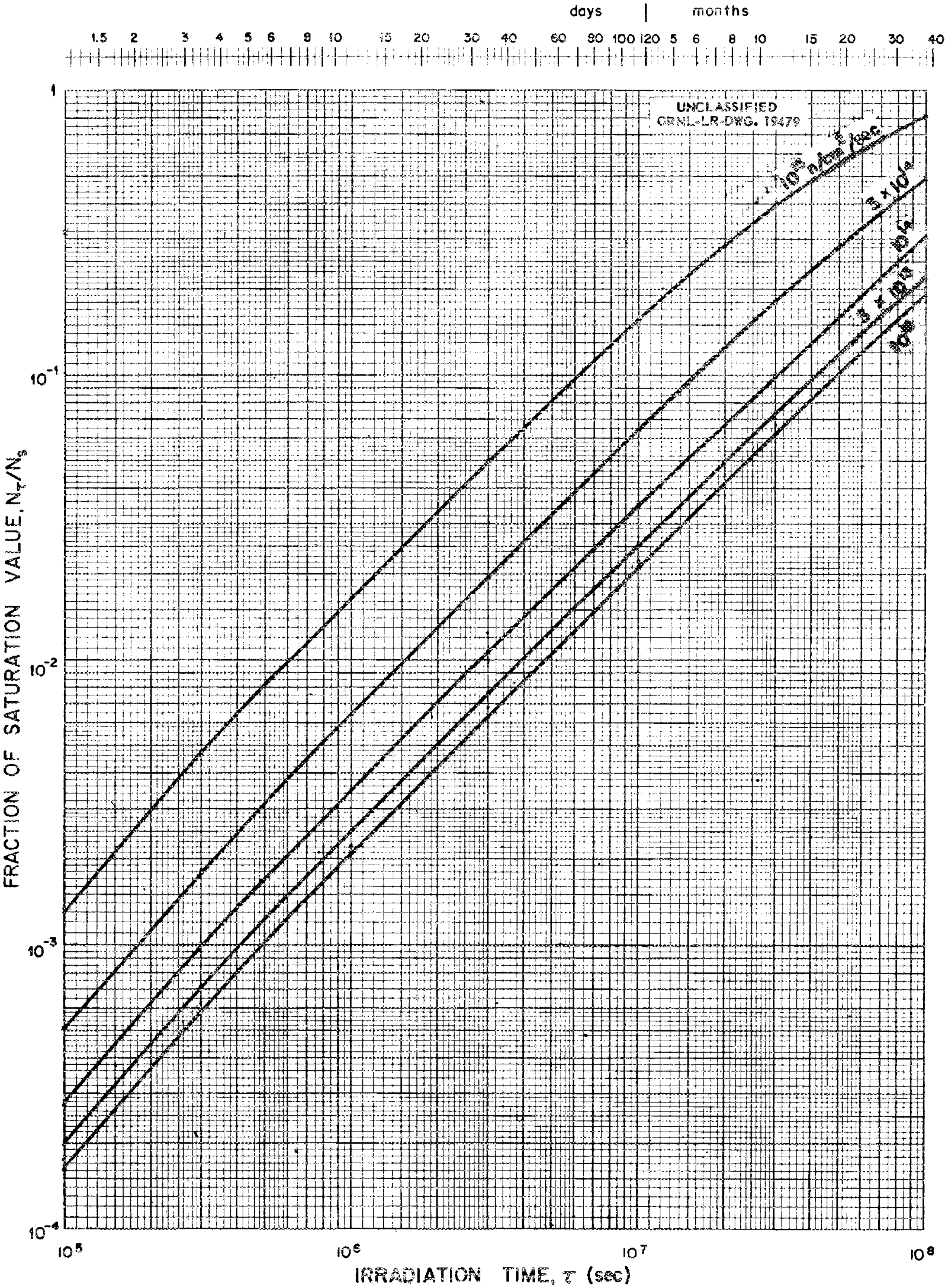

Fig. B-10. Fraction of Saturation Value of 10.27y Kr^{85} as a Function of Irradiation Time and Flux.

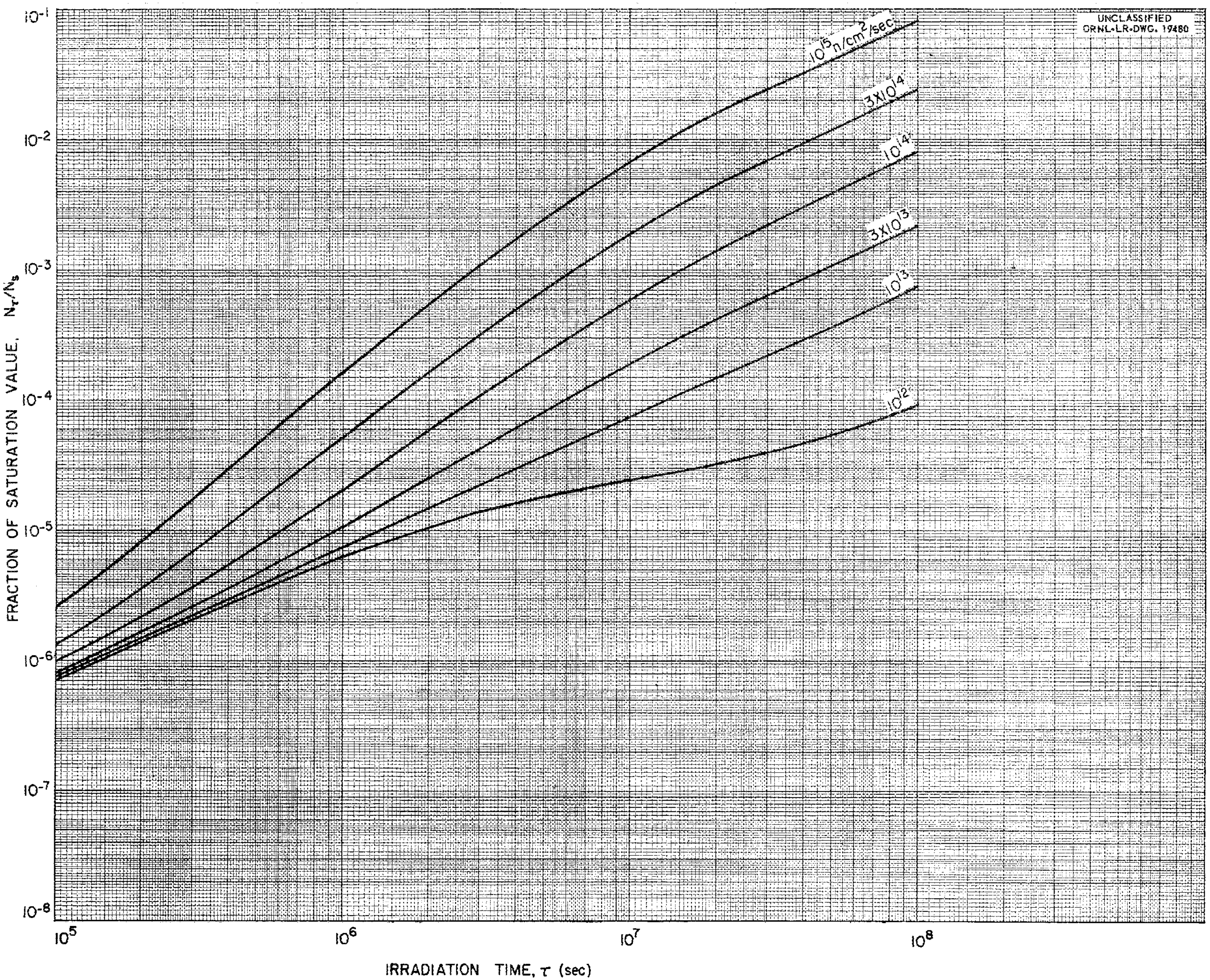

Fig. B—11. Fraction of Saturation Value of 19.5d Rb^{86} as a Function of Irradiation Time and Flux.

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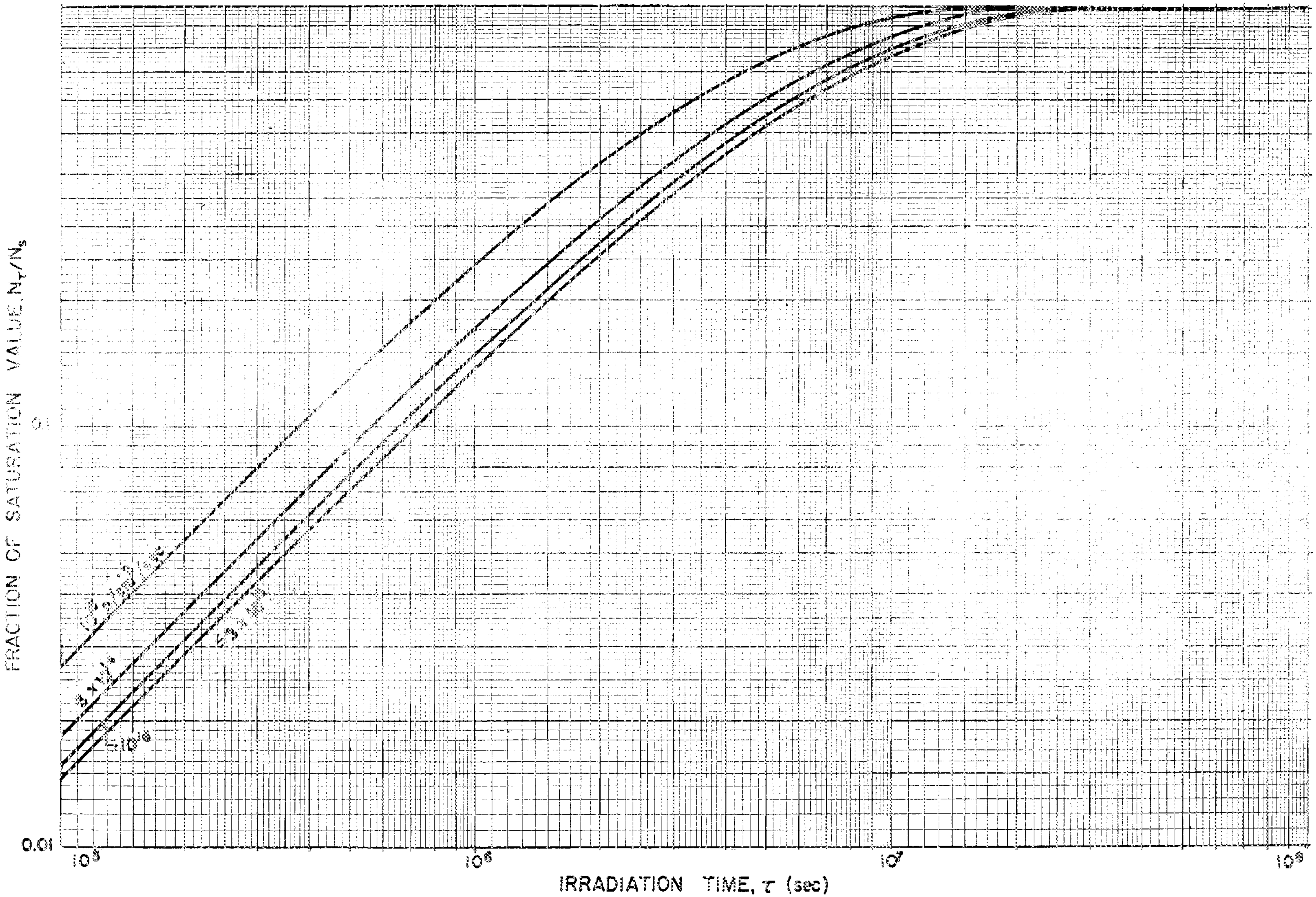

Fig. B-12. Fraction of Saturation Value of 54d Sr^{89} as a Function of Irradiation Time and Flux.

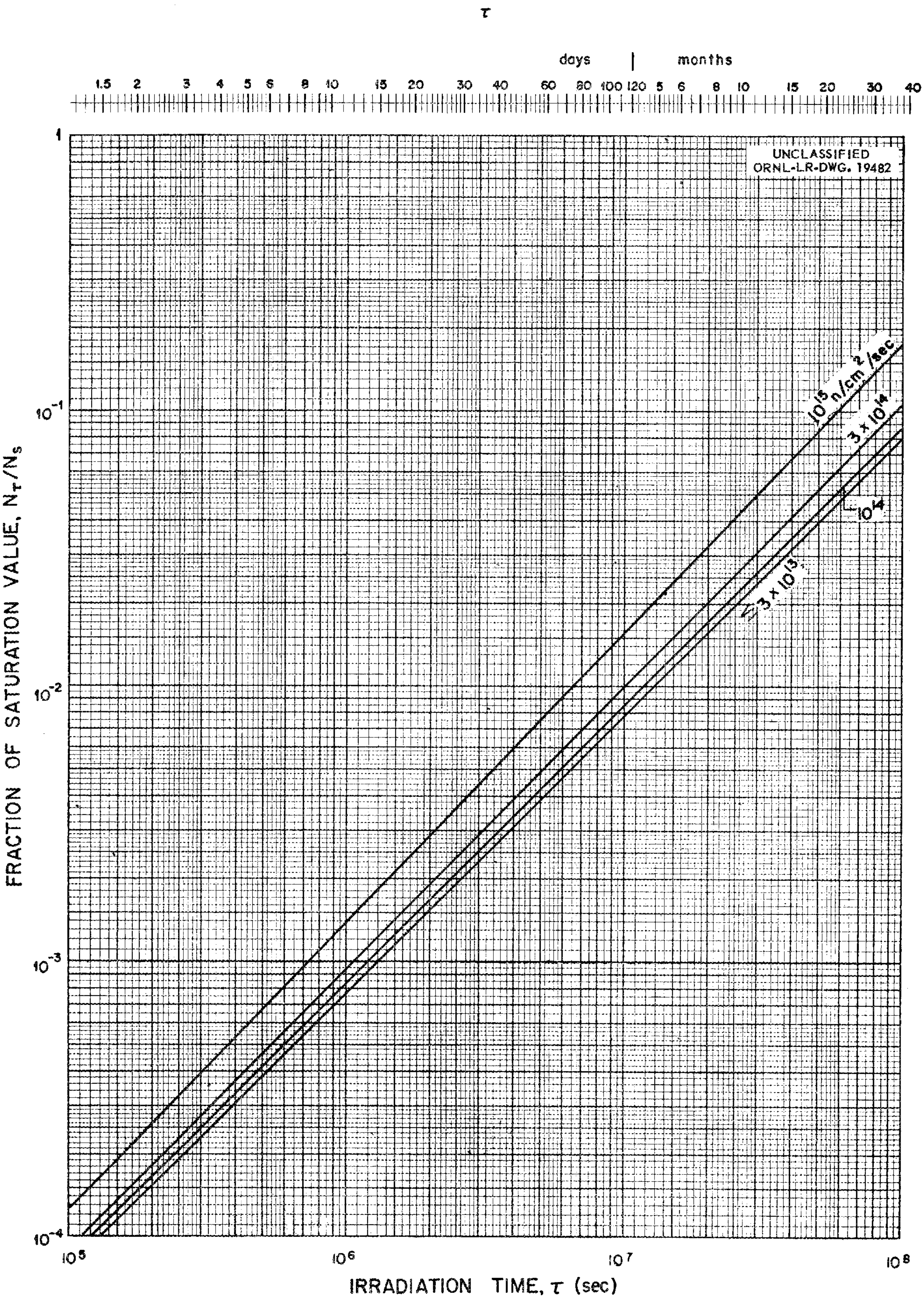

Fig. B-13. Fraction of Saturation Value of 28y Sr^{90} as a Function of Irradiation Time and Flux.

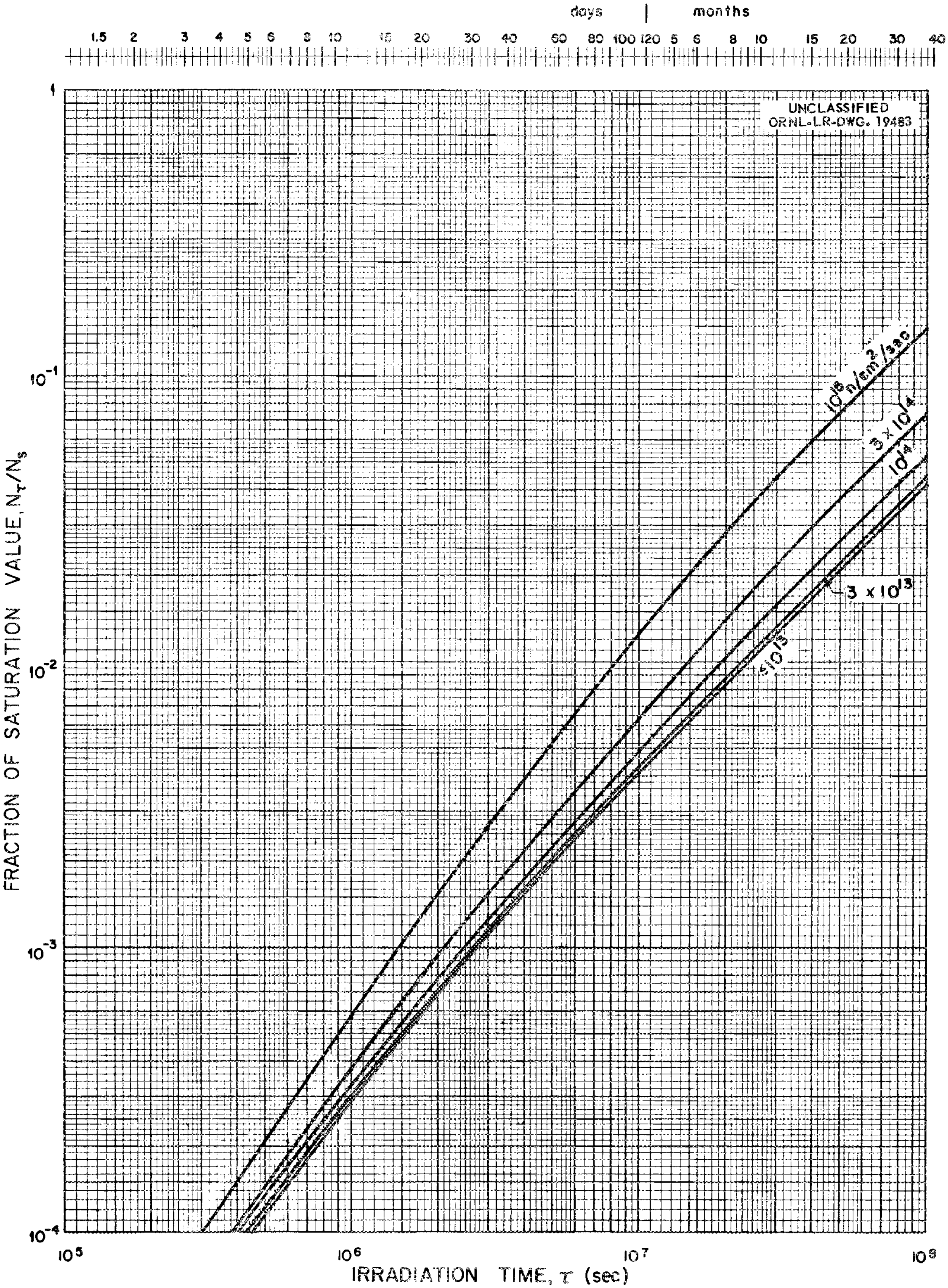

Fig. B-14. Fraction of Saturation Value of 64.5h Y^{90} as a Function of Irradiation Time and Flux.

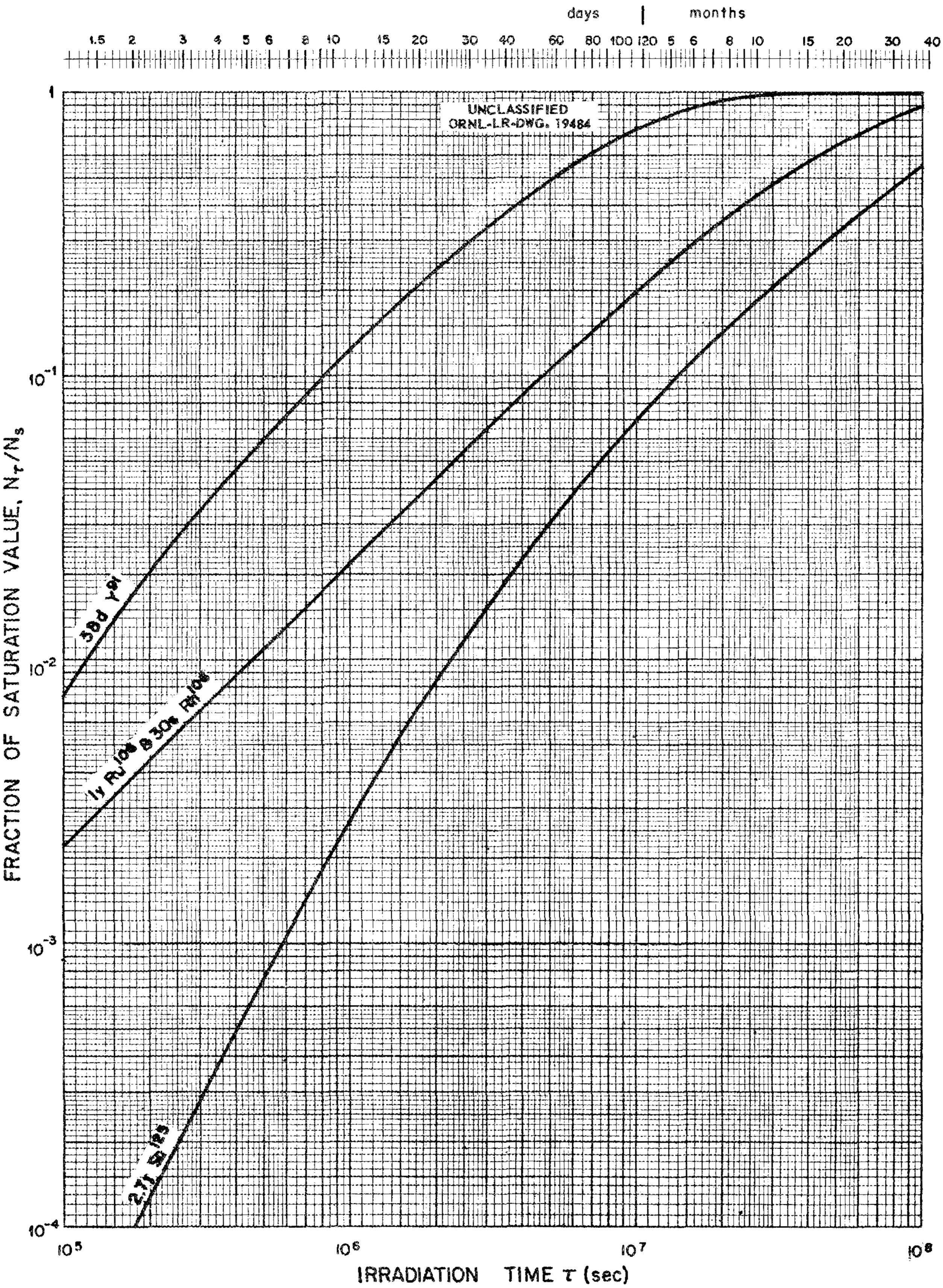

Fig. B-15. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

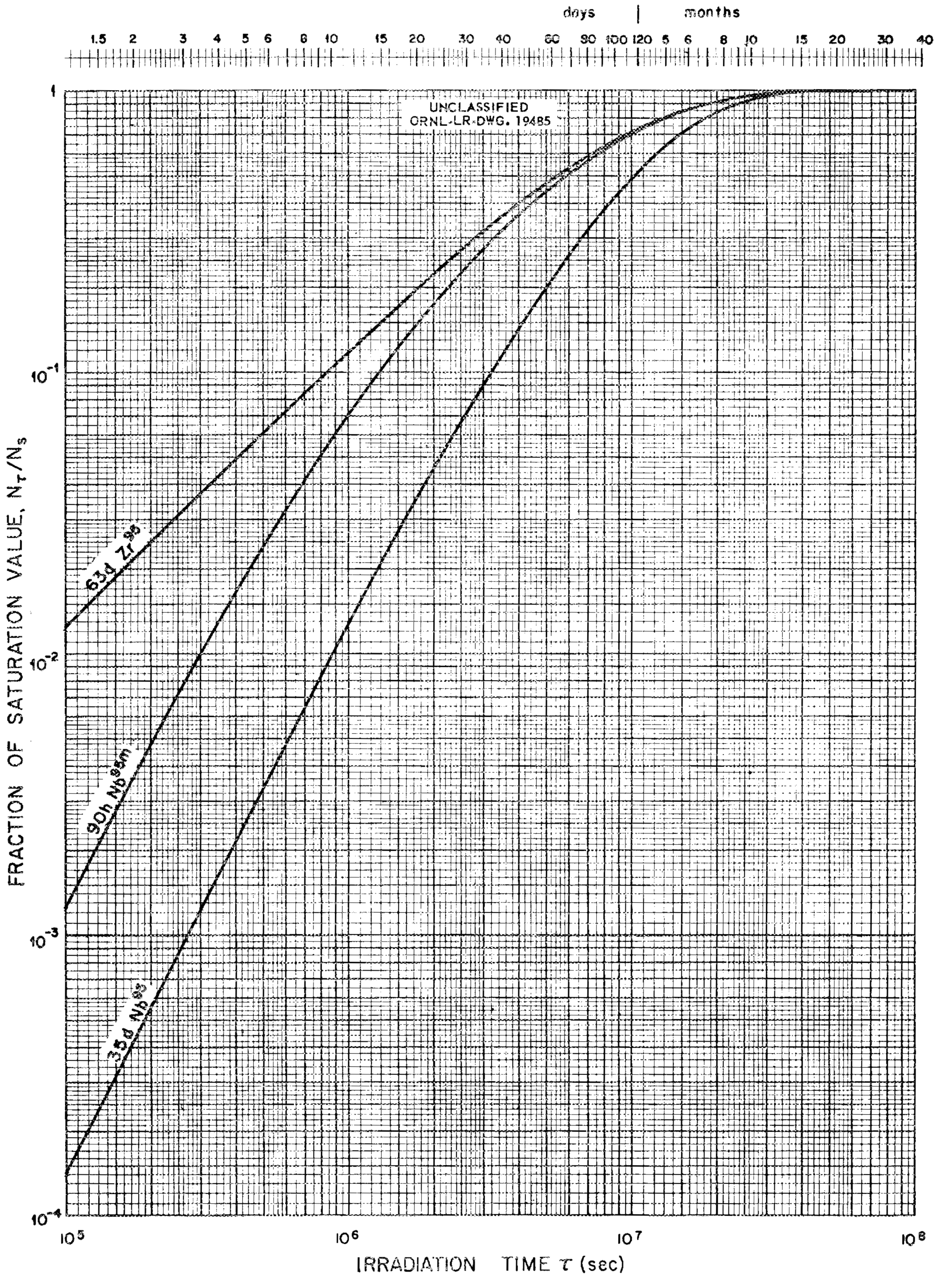

Fig. B-16. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

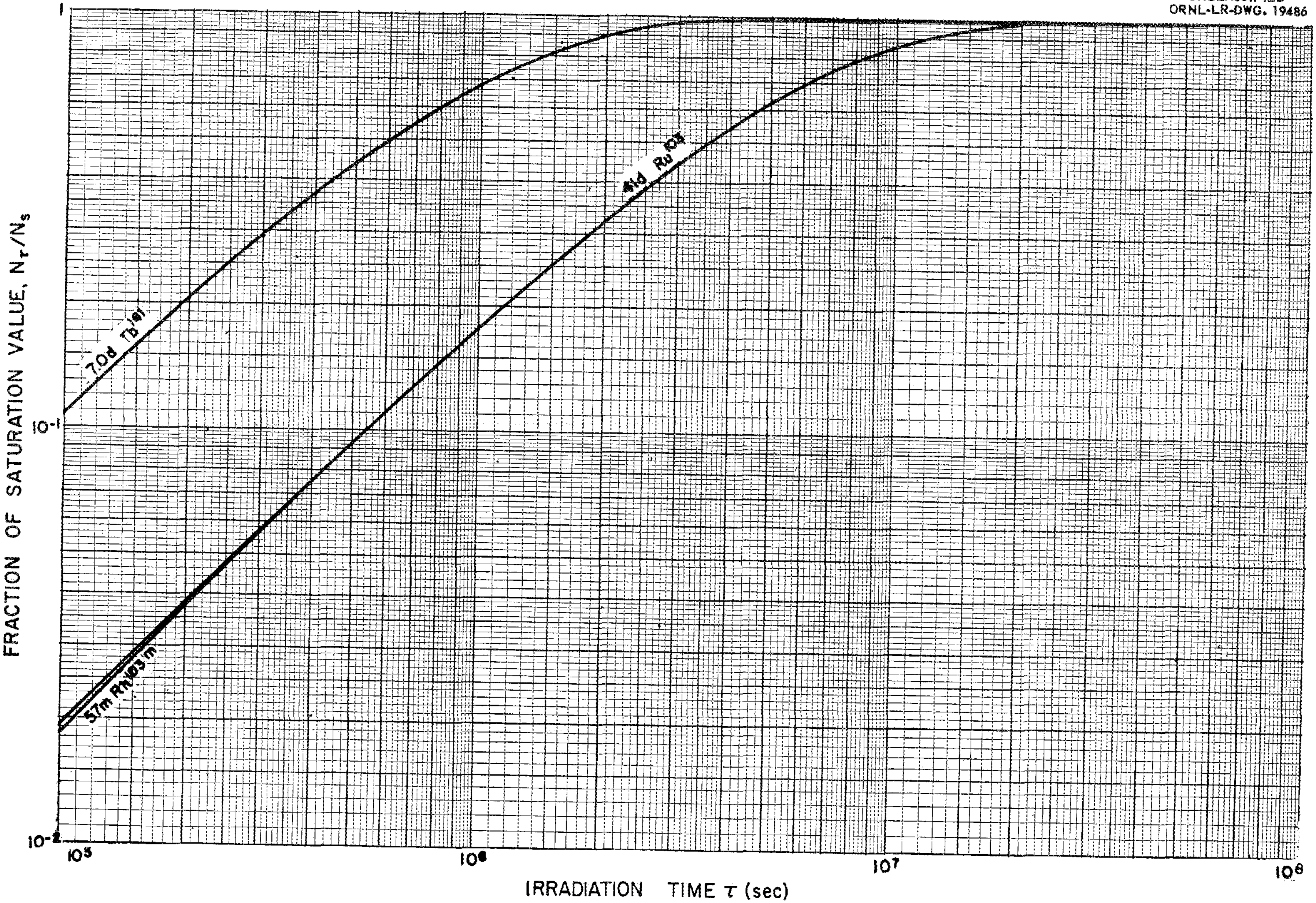

Fig. B-17. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

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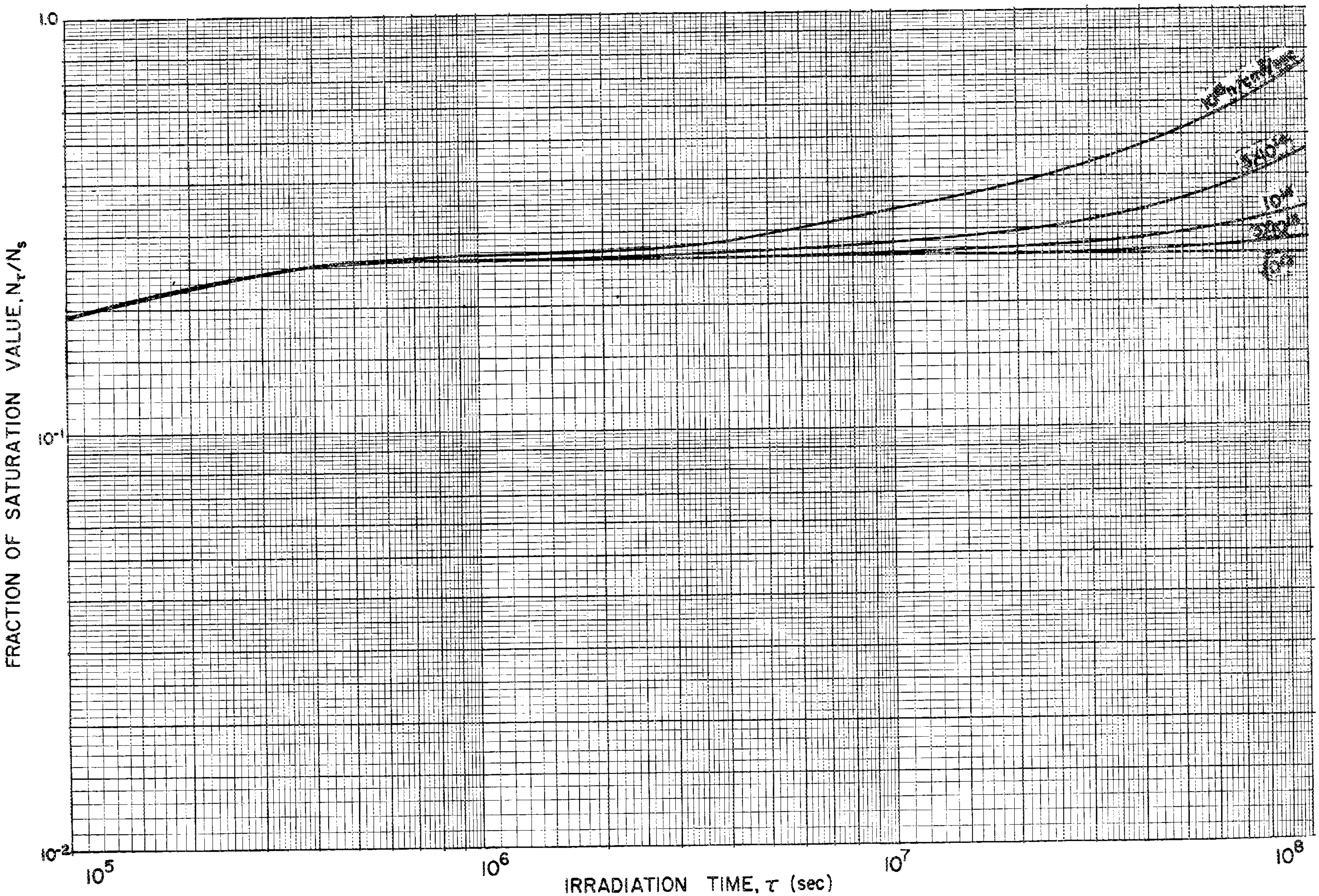

Fig. B-18. Fraction of Saturation Value of 13.6h Pd^{109} & 39.2s Ag^{109m} as a Function of Irradiation Time and Flux.

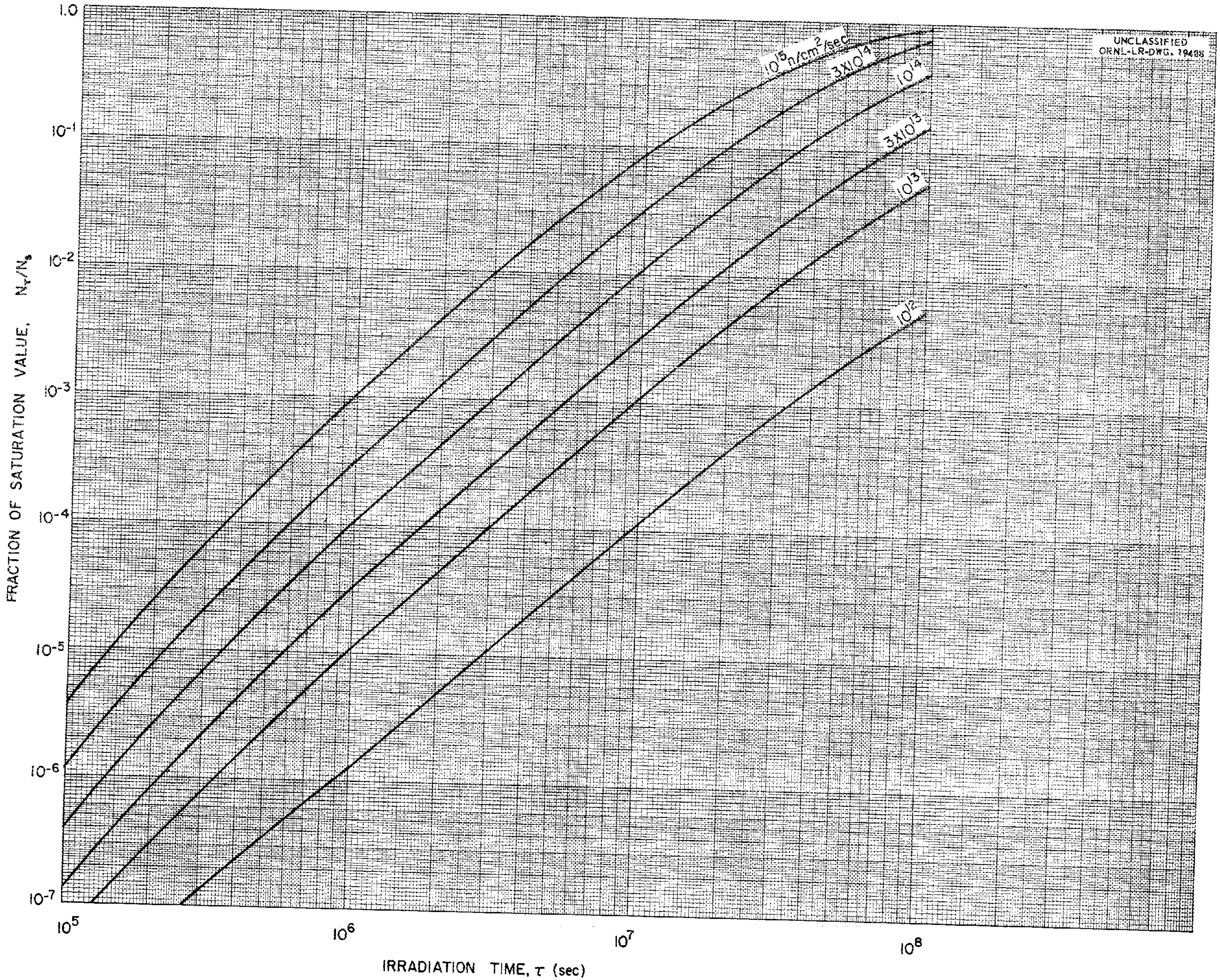

Fig. B-19. Fraction of Saturation Value of 270d Ag^{110m}* as a Function of Irradiation Time and Flux.

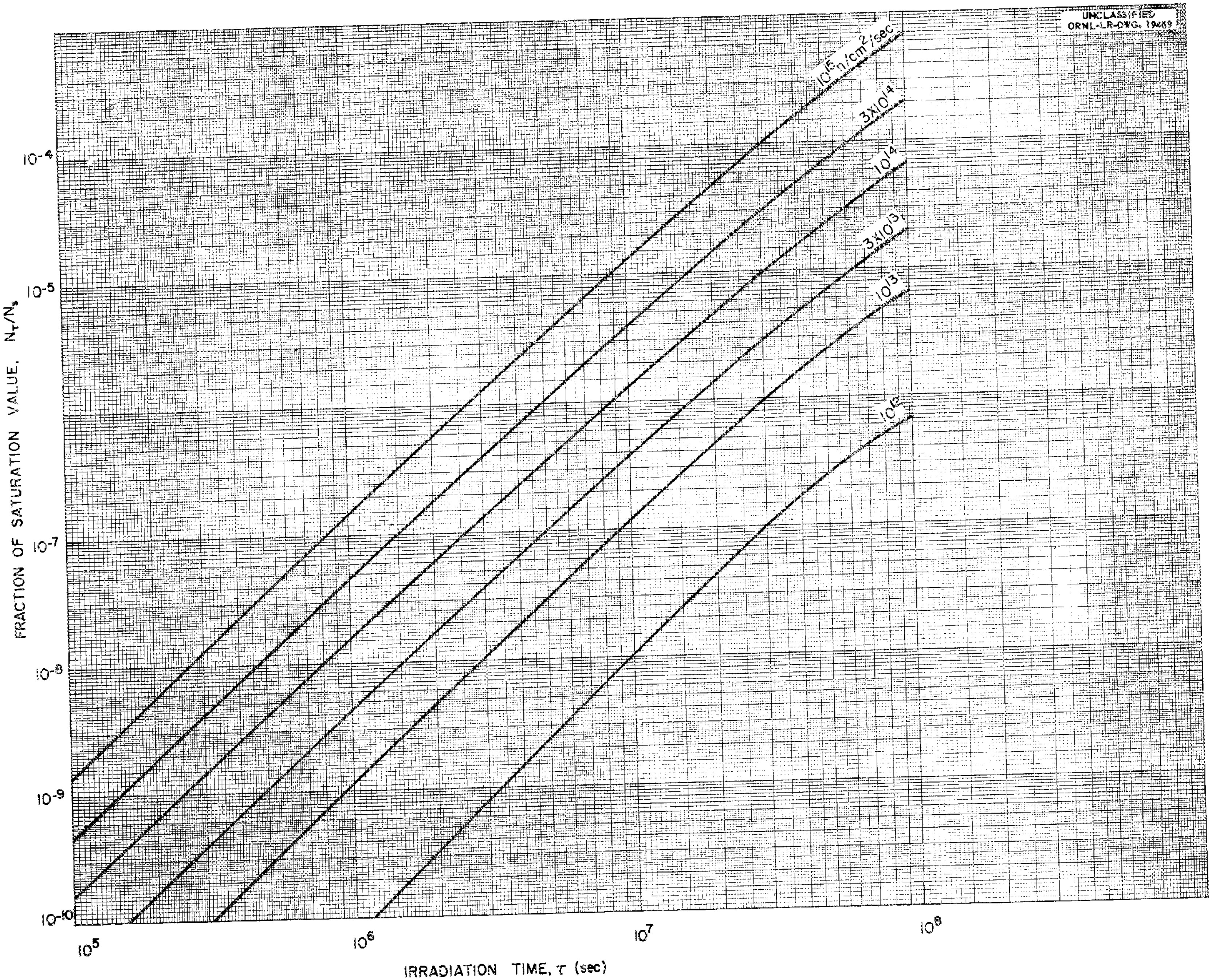

Fig. B–20. Fraction of Saturation Value of 275d Sn^{119m} as a Function of Irradiation Time and Flux.

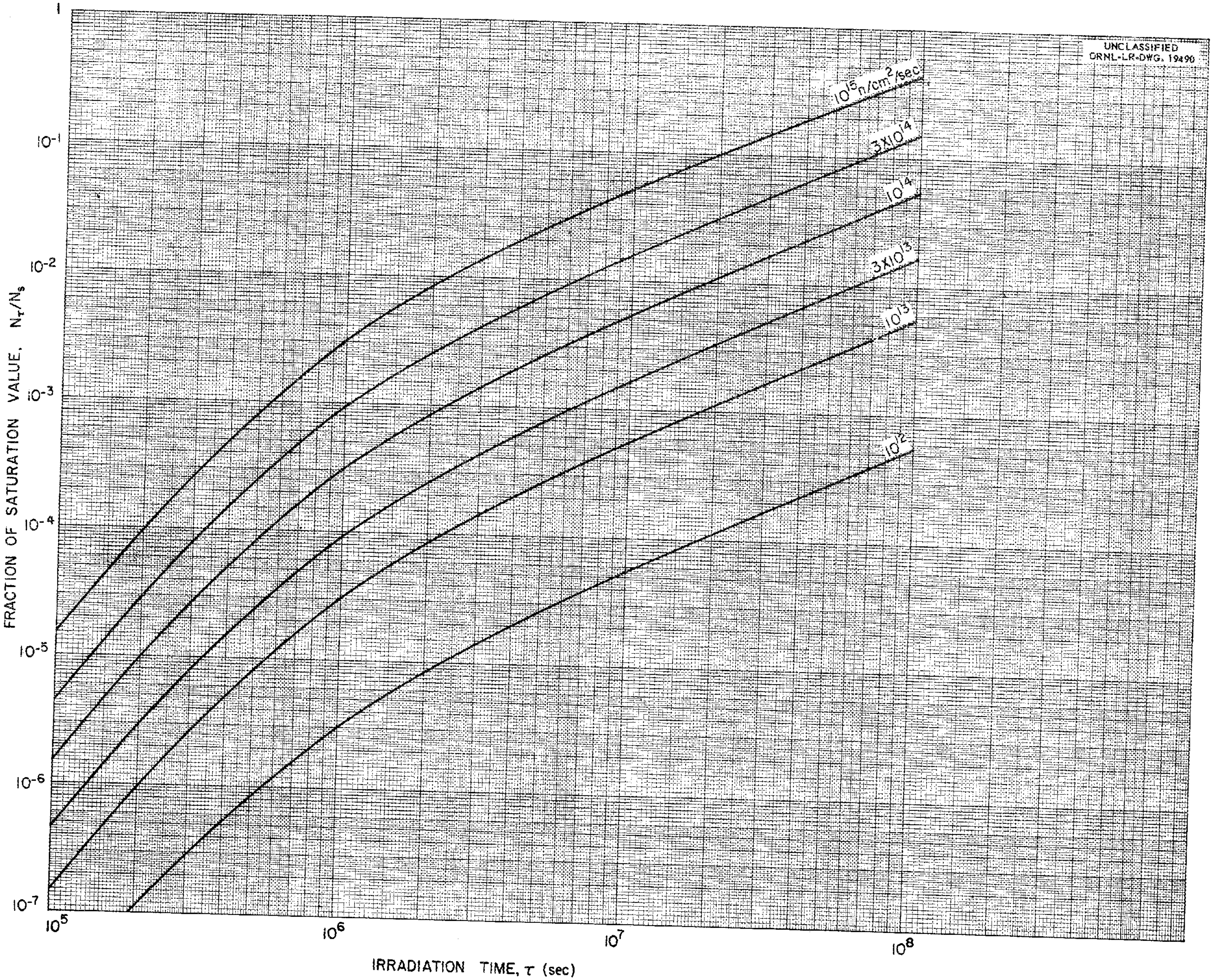

Fig. 8-21. Fraction of Saturation Value of 2.75d Sb^{122} * as a Function of Irradiation Time and Flux.

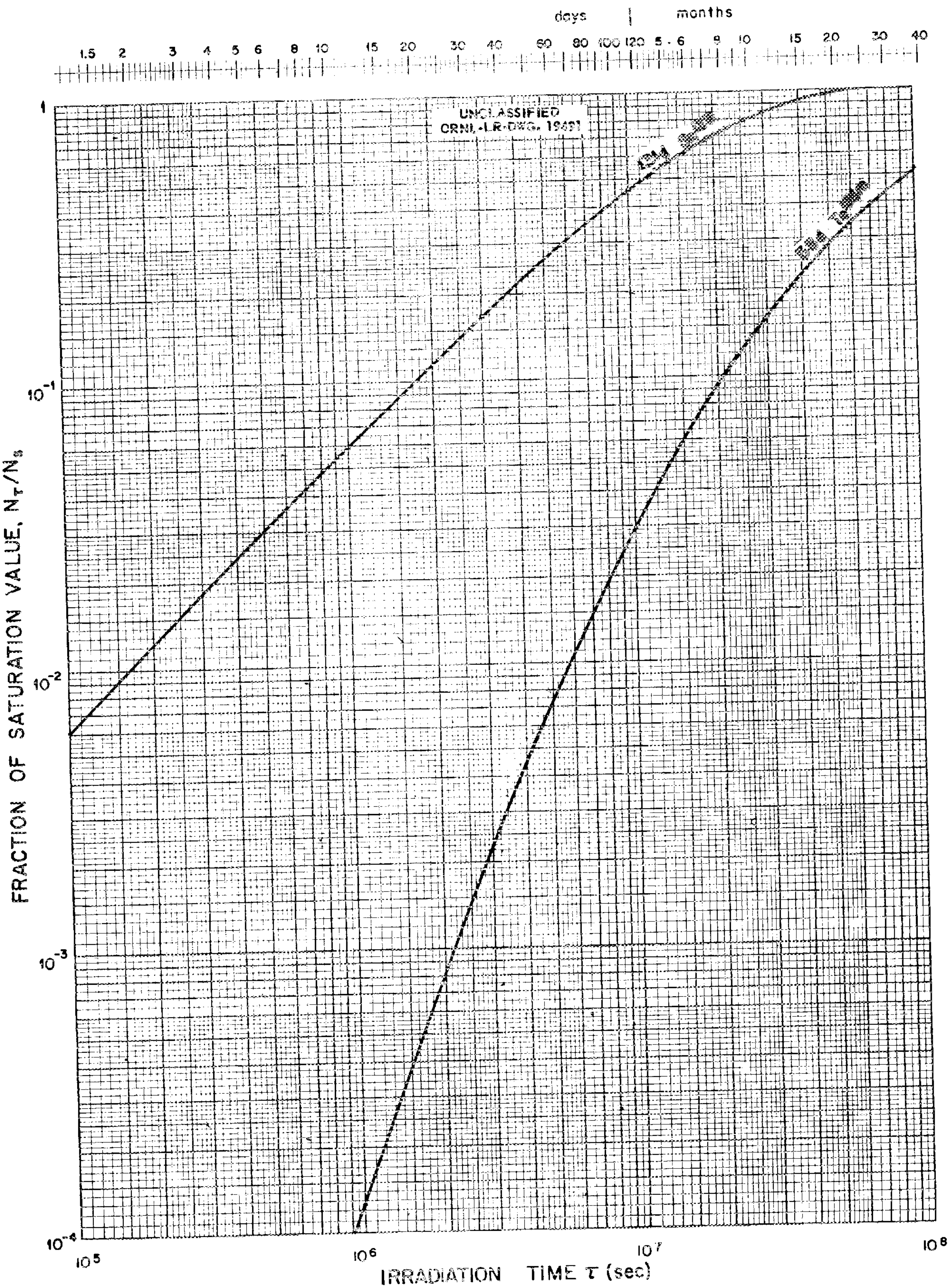

Fig. B-22. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

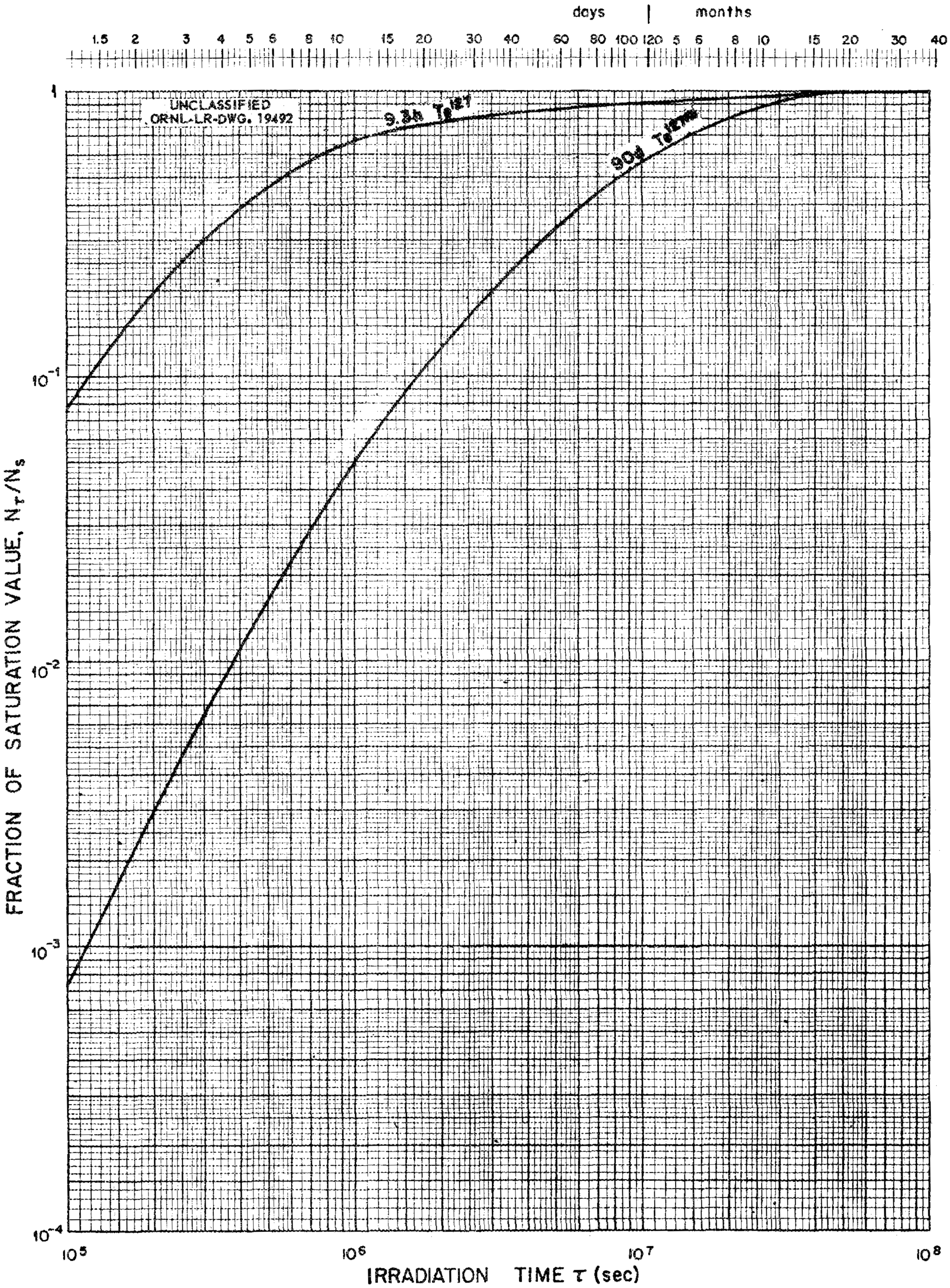

Fig. B-23. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

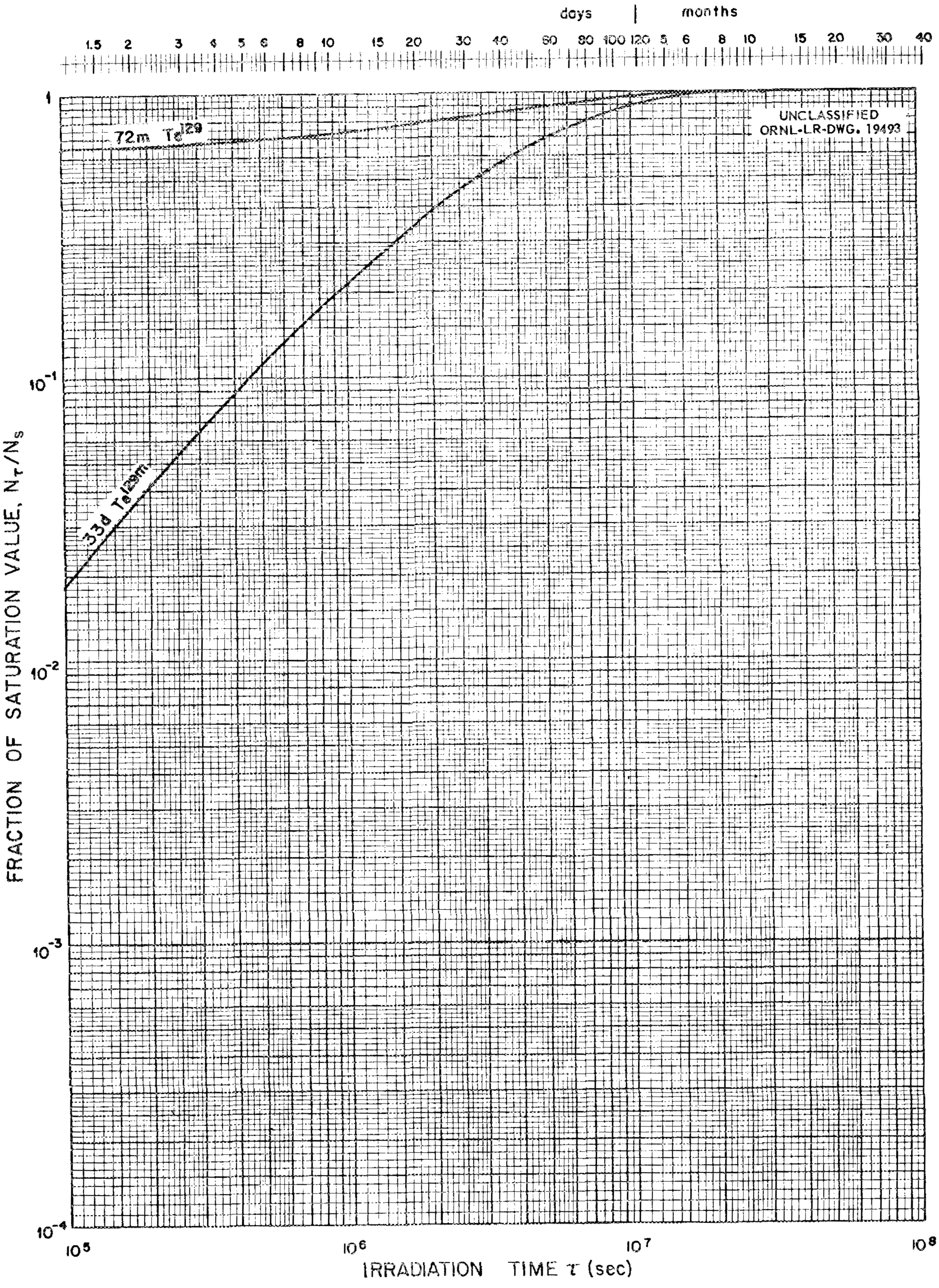

Fig. B-24. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

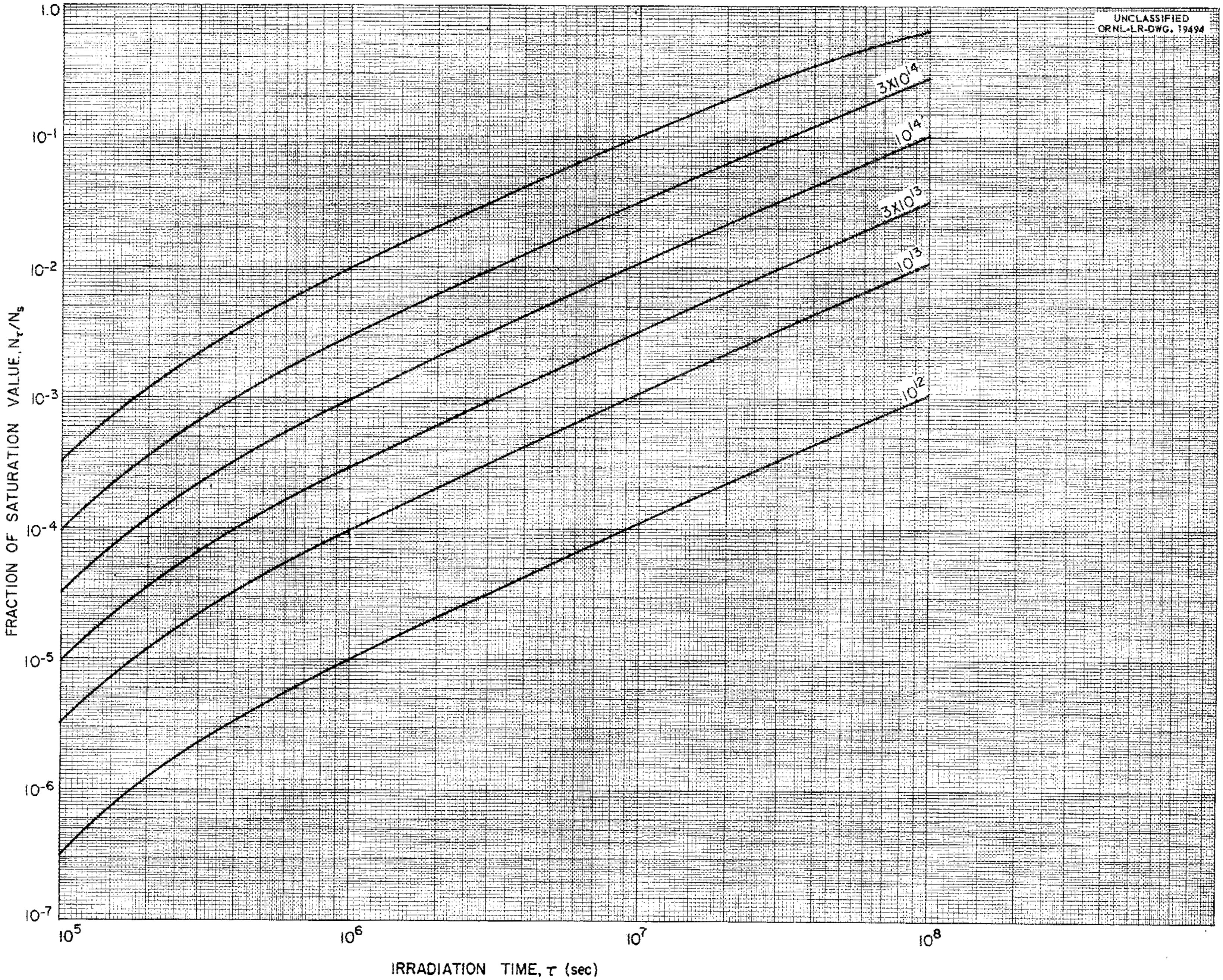

Fig. B-25. Fraction of Saturation Value of 12.6h I^{130*} as a Function of Irradiation Time and Flux.

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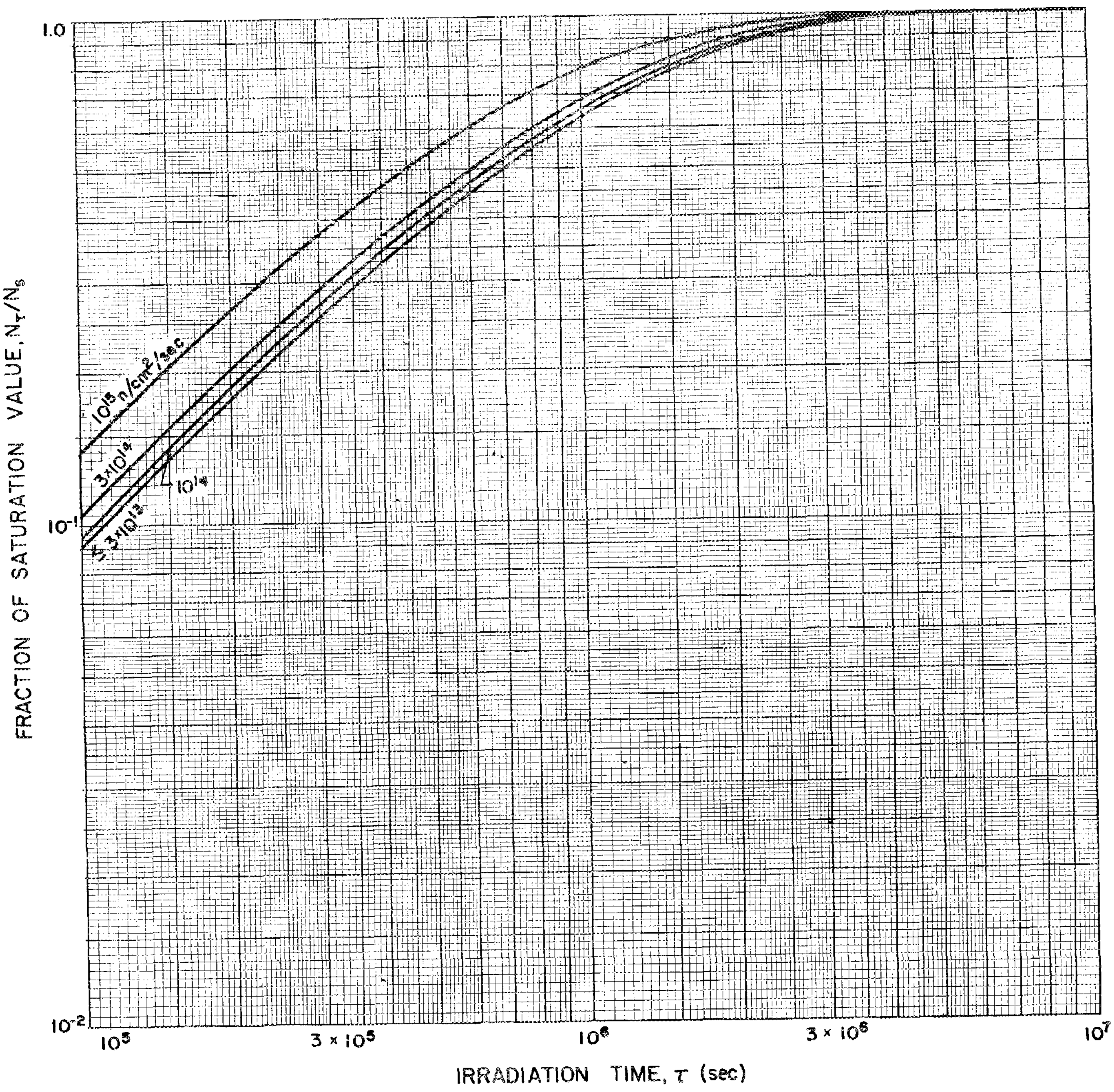

Fig. B-26. Fraction of Saturation Value of 8.05 d I^{131} as a Function of Irradiation Time and Flux.

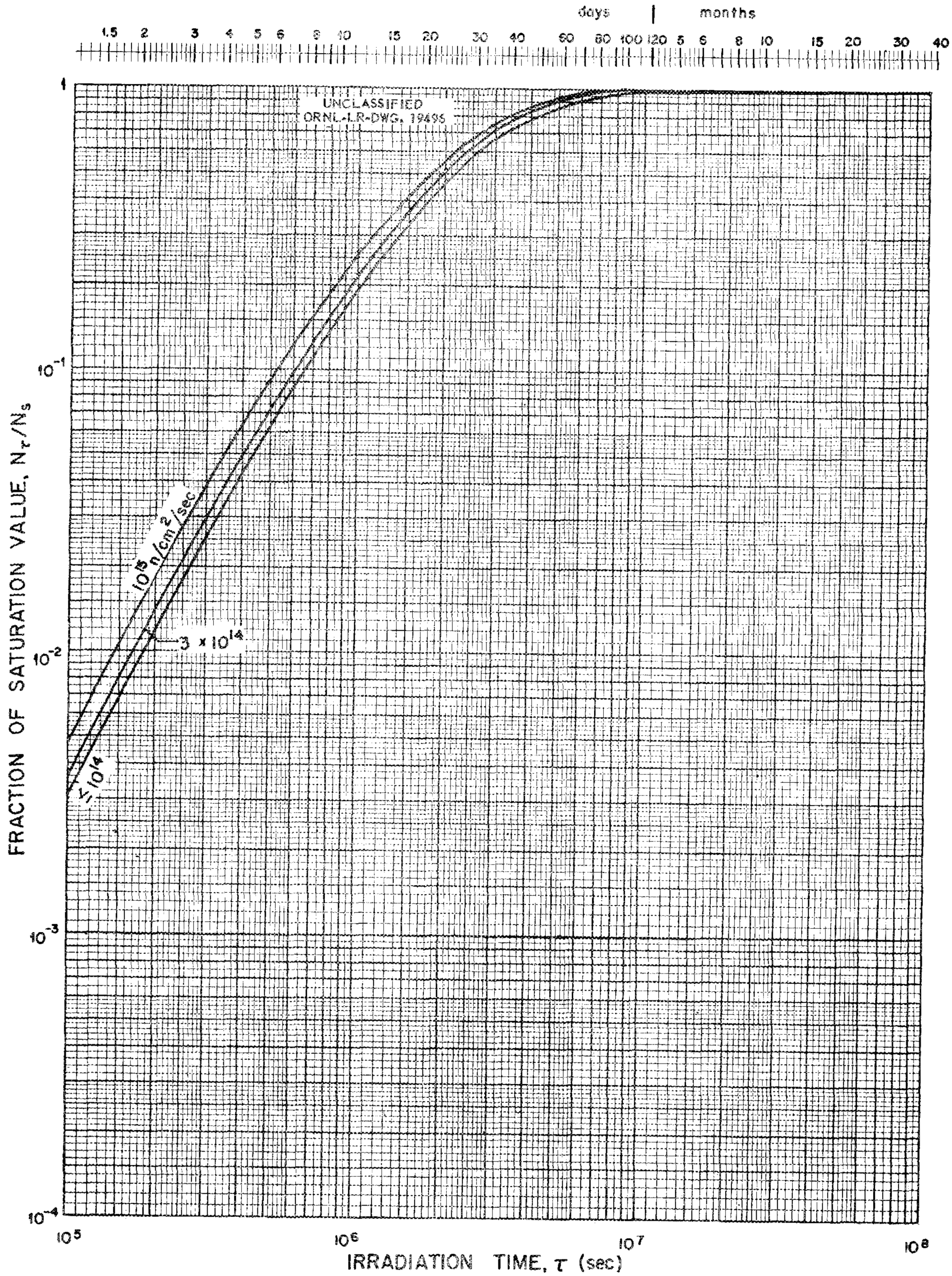

Fig. B-27. Fraction of Saturation Value of 12d Xe^{131m} as a Function of Irradiation Time and Flux.

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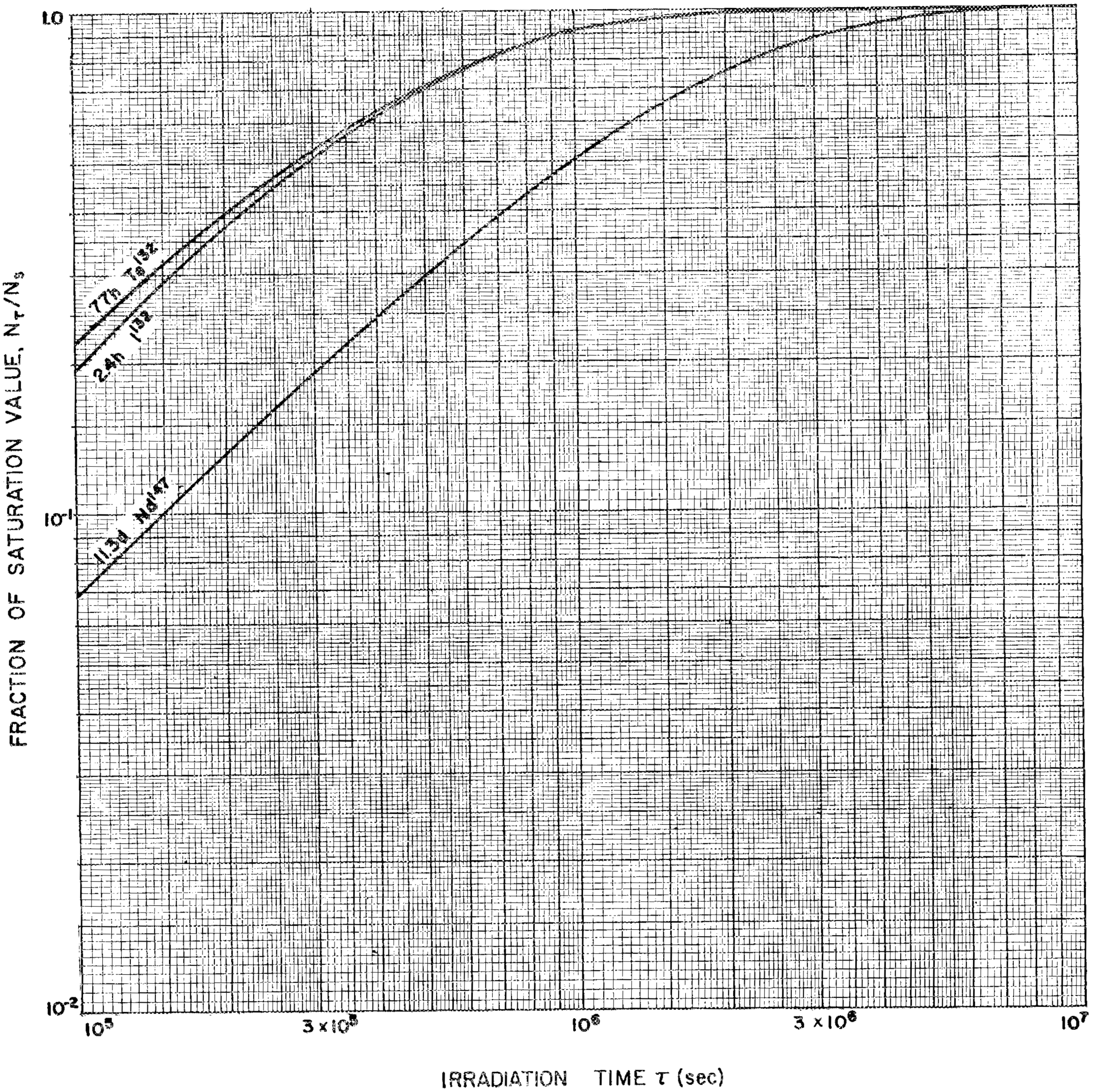

Fig. B-28. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

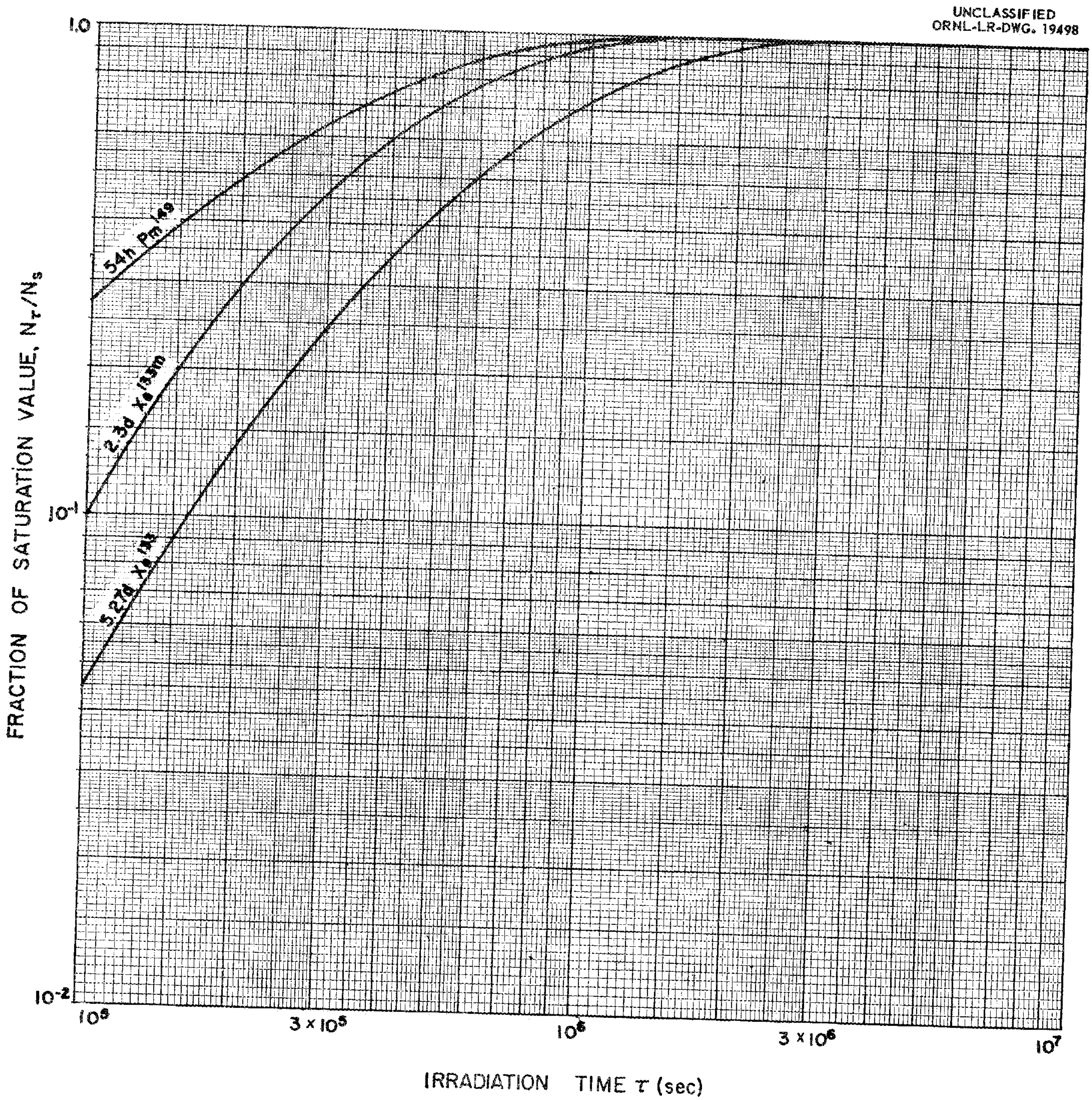

Fig. B-29. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

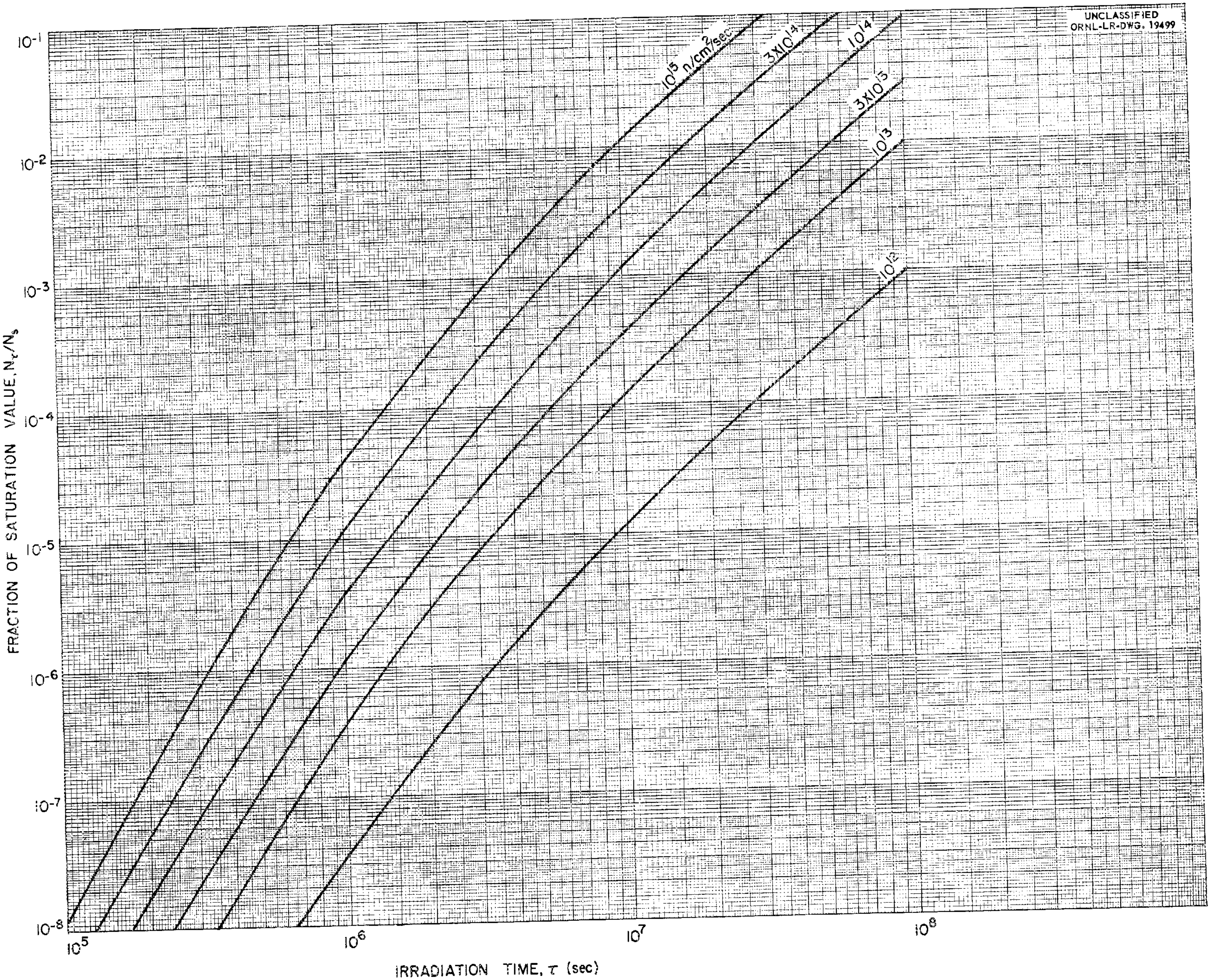

Fig. B-30. Fraction of Saturation Value of 2.0y Cs^{134*} as a Function of Irradiation Time and Flux.

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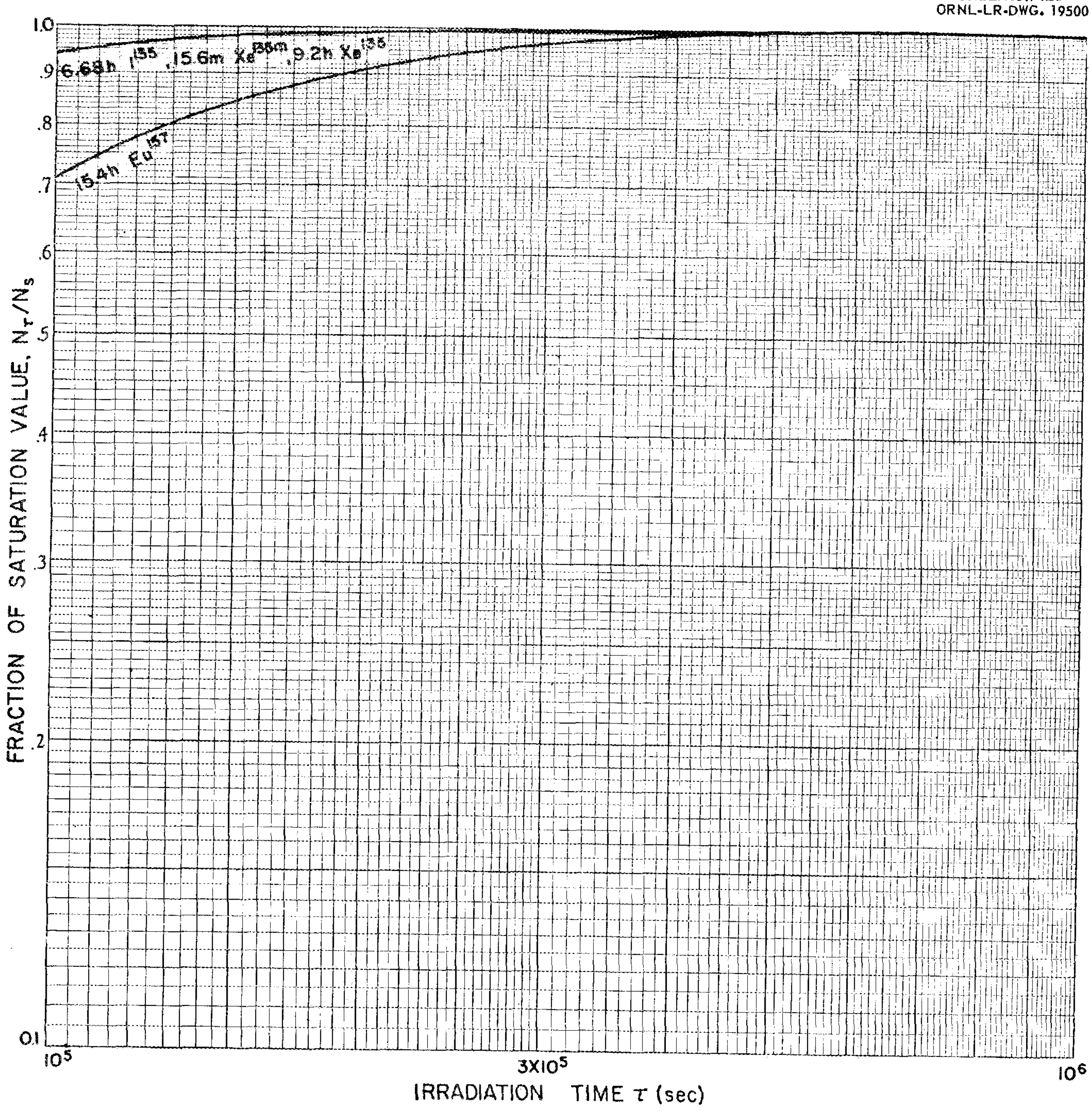

Fig. B-31. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

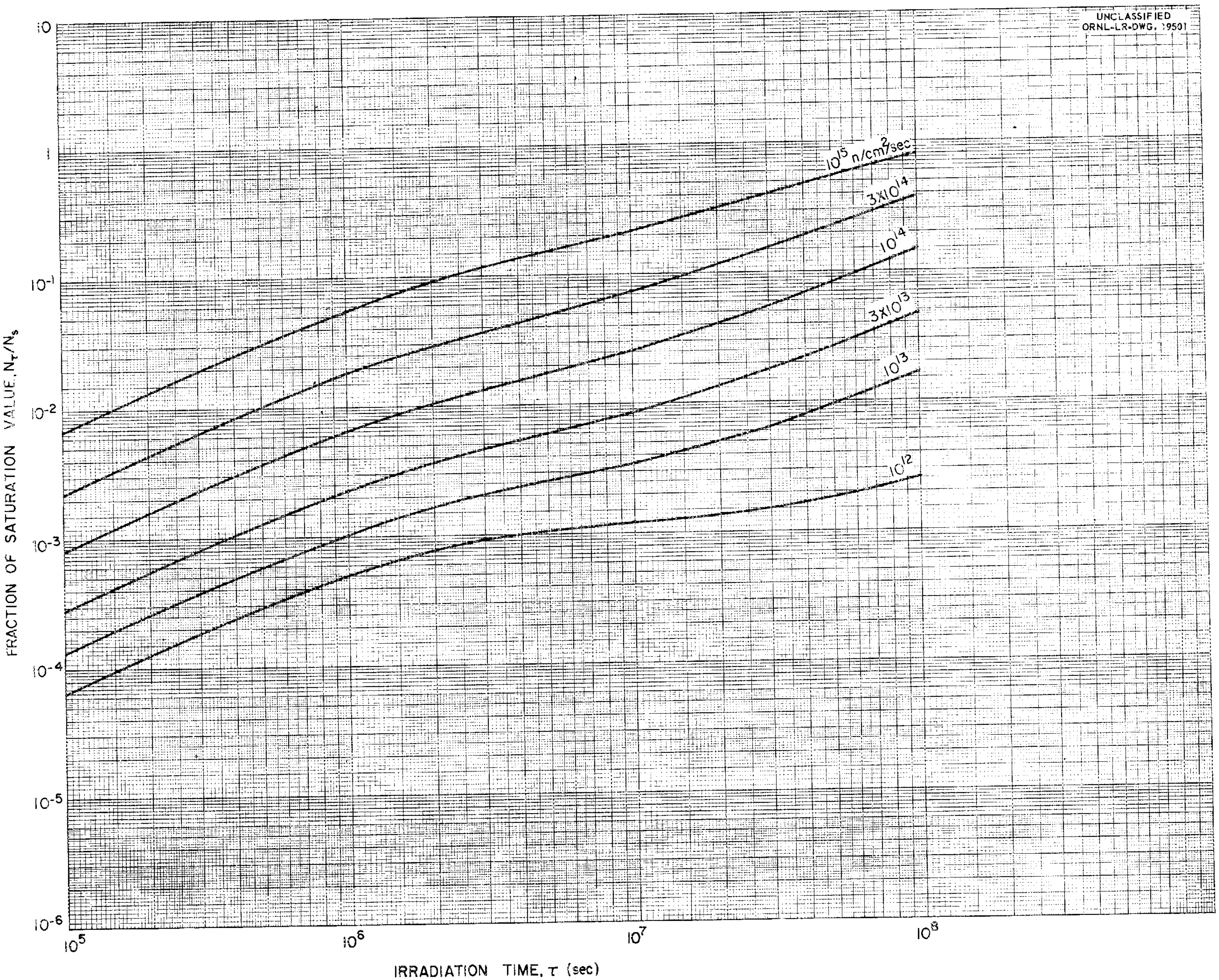

Fig. 8–32. Fraction of Saturation Value of 13d Cs^{136*} as a Function of Irradiation Time and Flux.

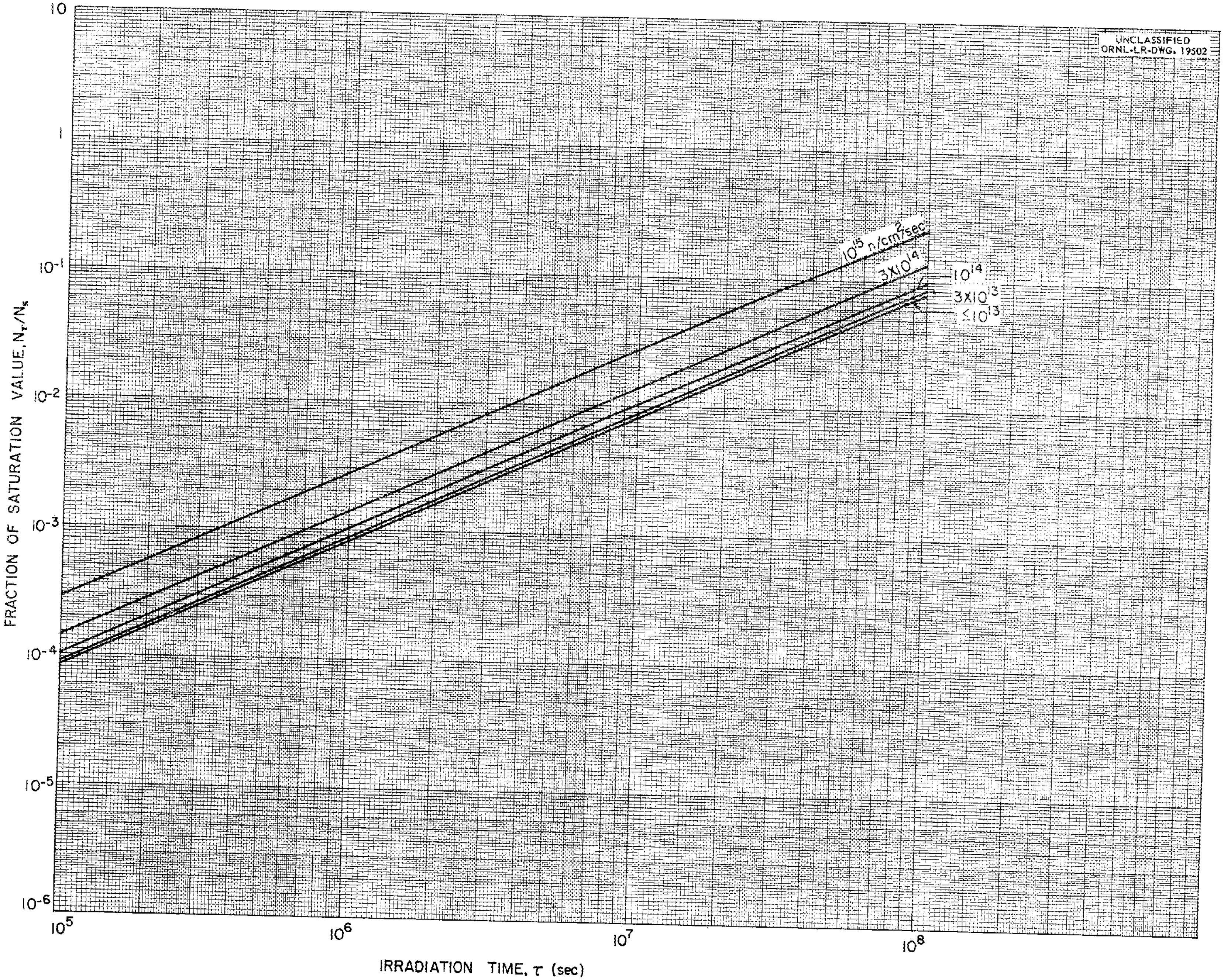

Fig. B-33. Fraction of Saturation Value of 26.6y Cs^{137} & 2.60m Ba^{137m} as a Function of Irradiation Time and Flux.

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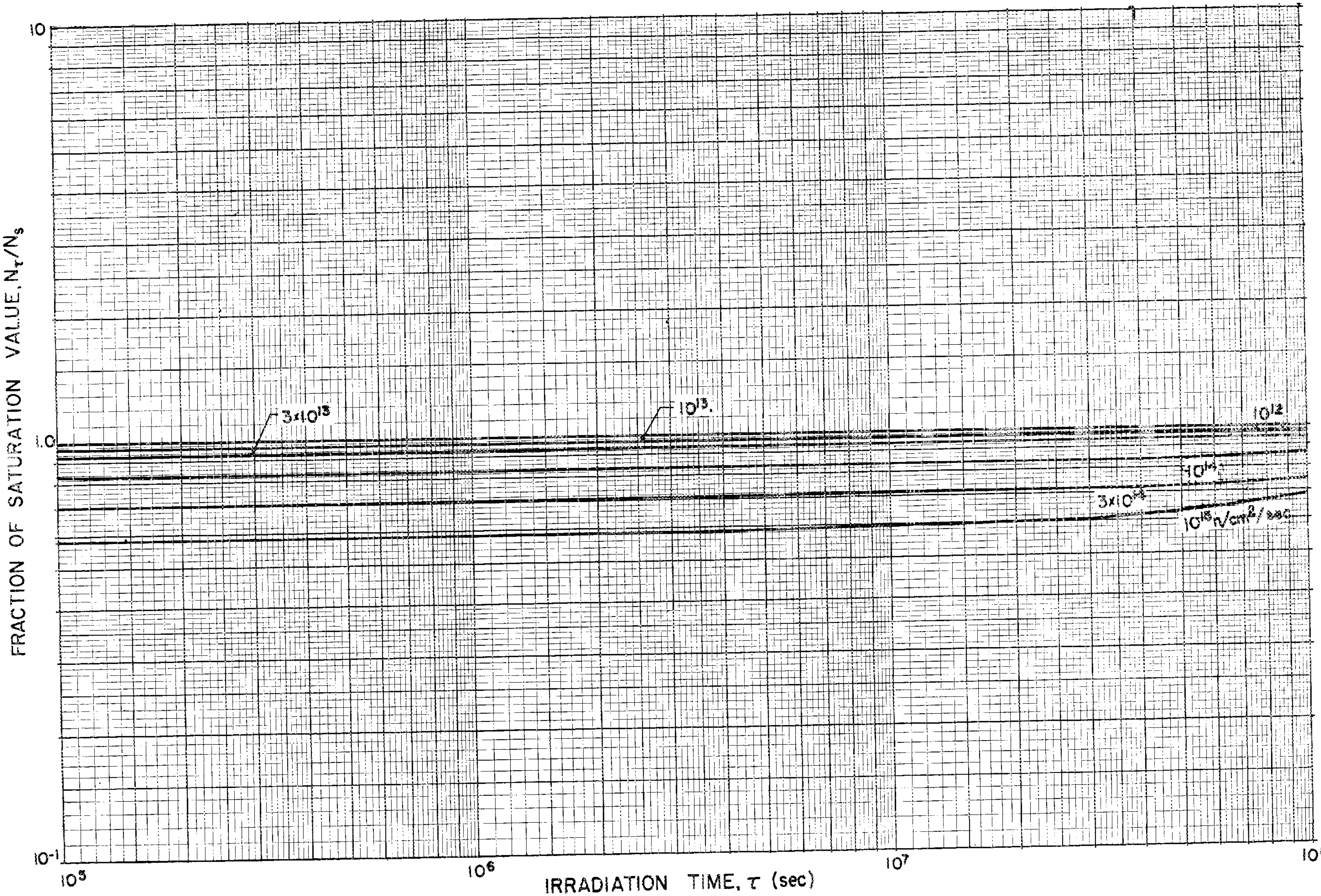

Fig. B-34. Fraction of Saturation Value of 32m Cs^{138} as a Function of Irradiation Time and Flux.

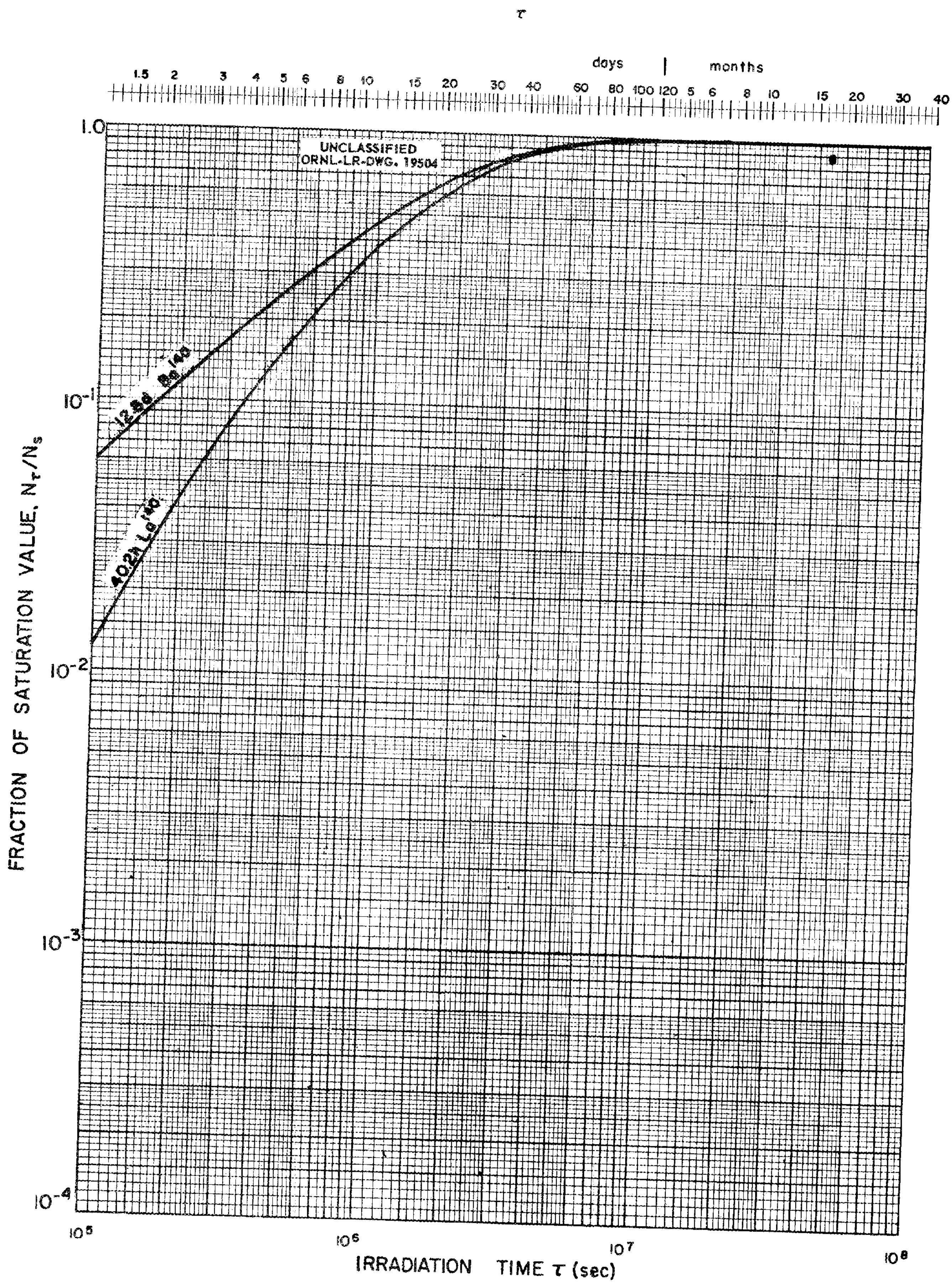

Fig. B-35. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

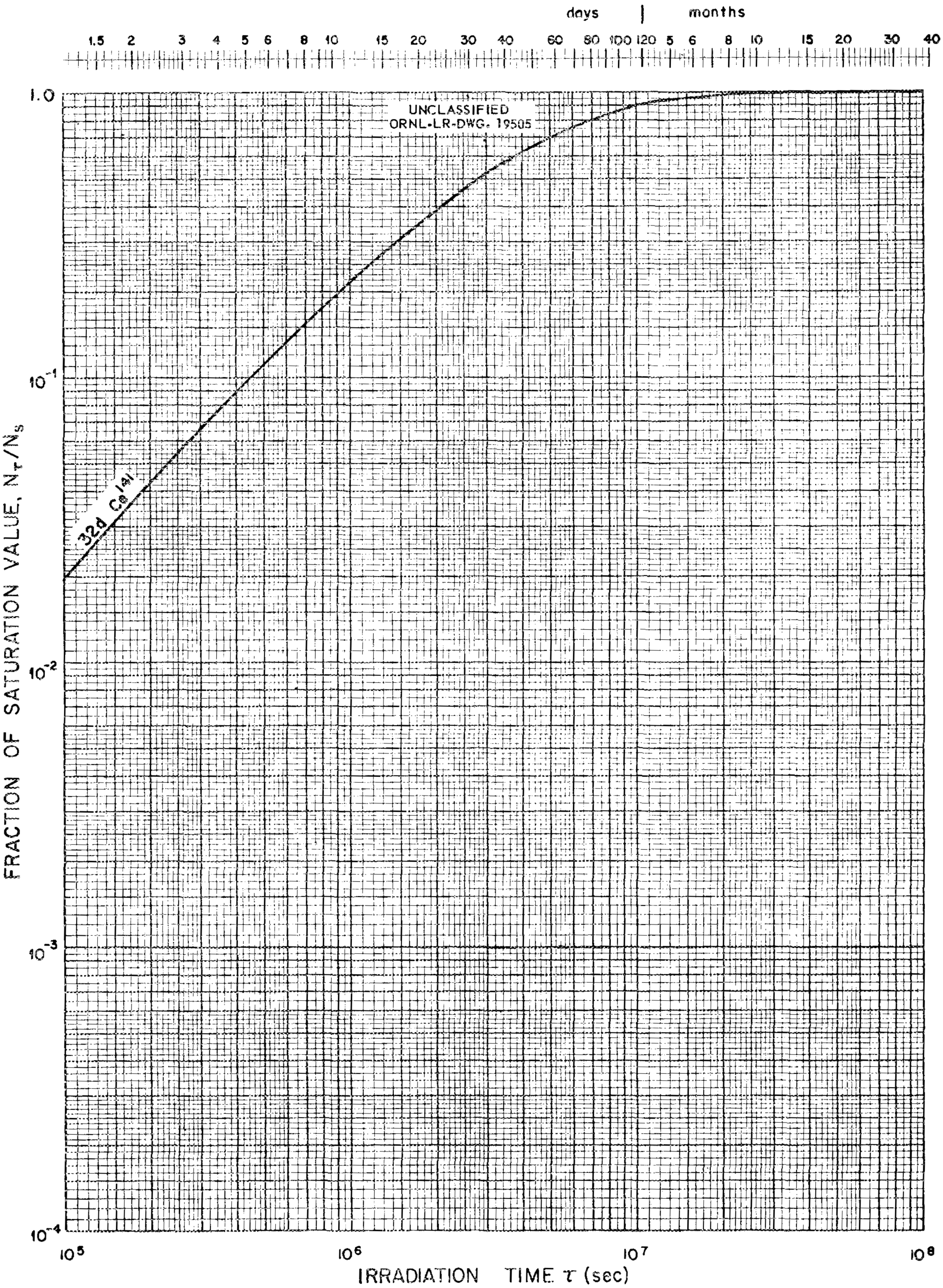

Fig. B-36. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

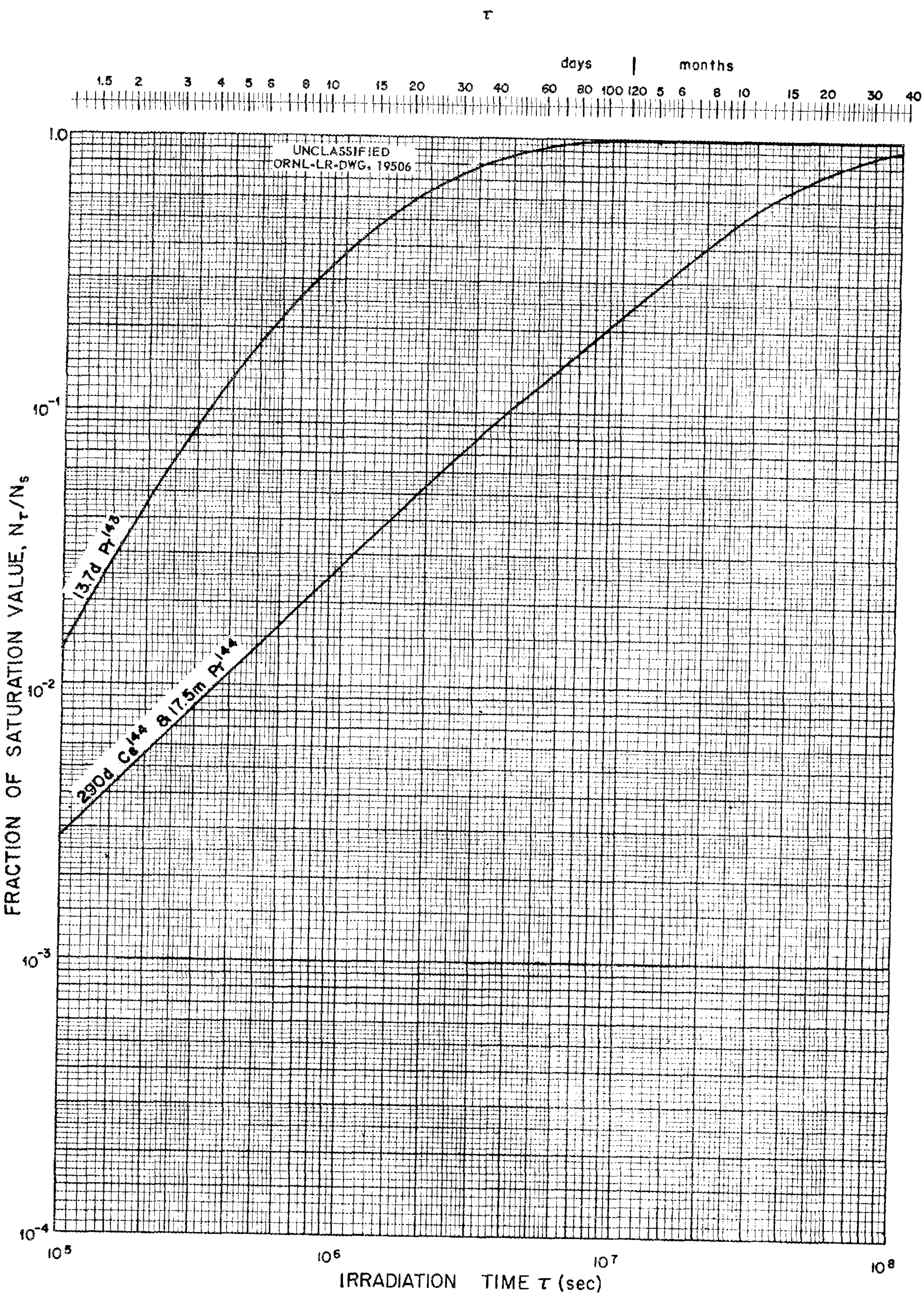

Fig. B-37. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

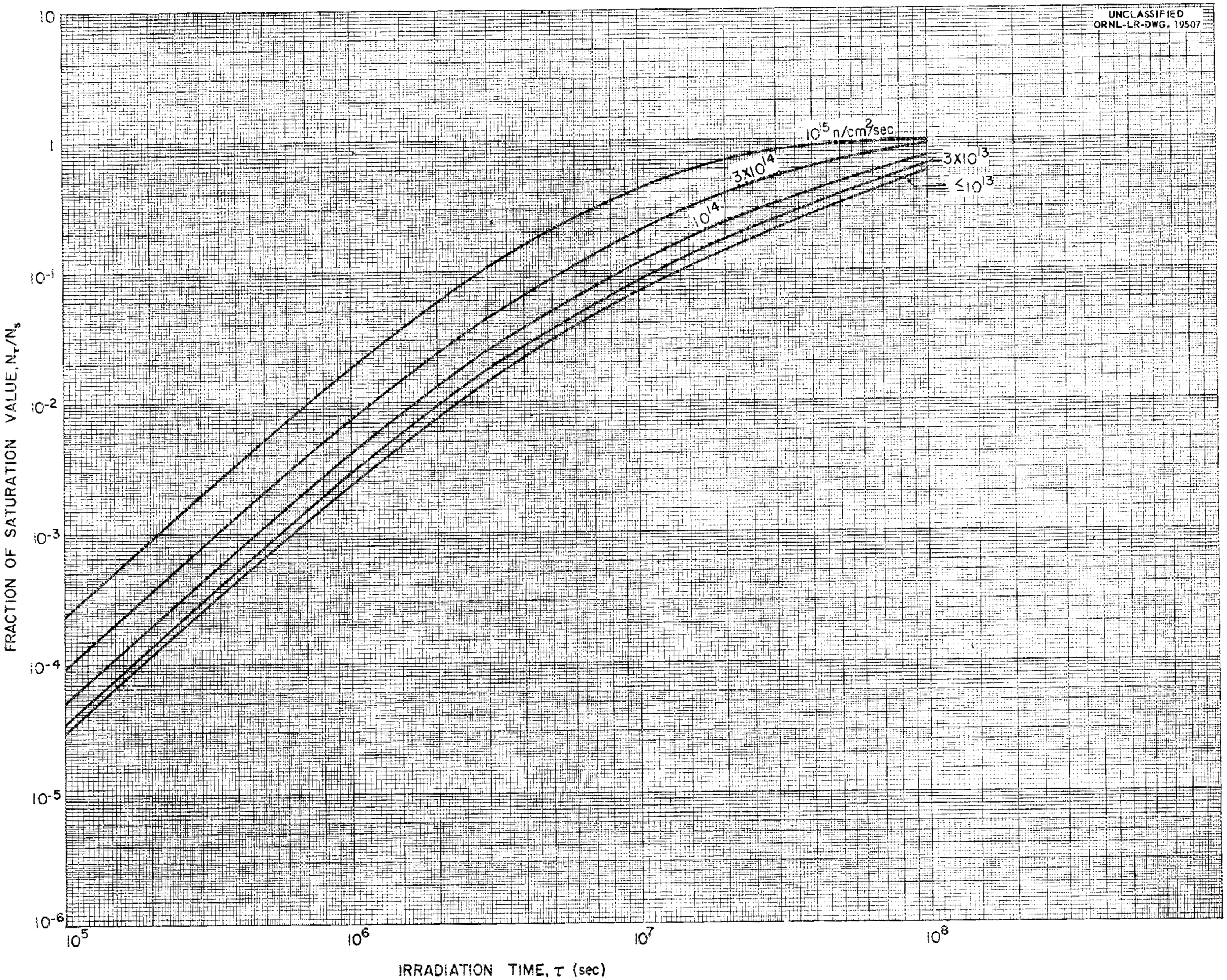

Fig. B-38. Fraction of Saturation Value of 2.6y Pm^{147} as a Function of Irradiation Time and Flux.

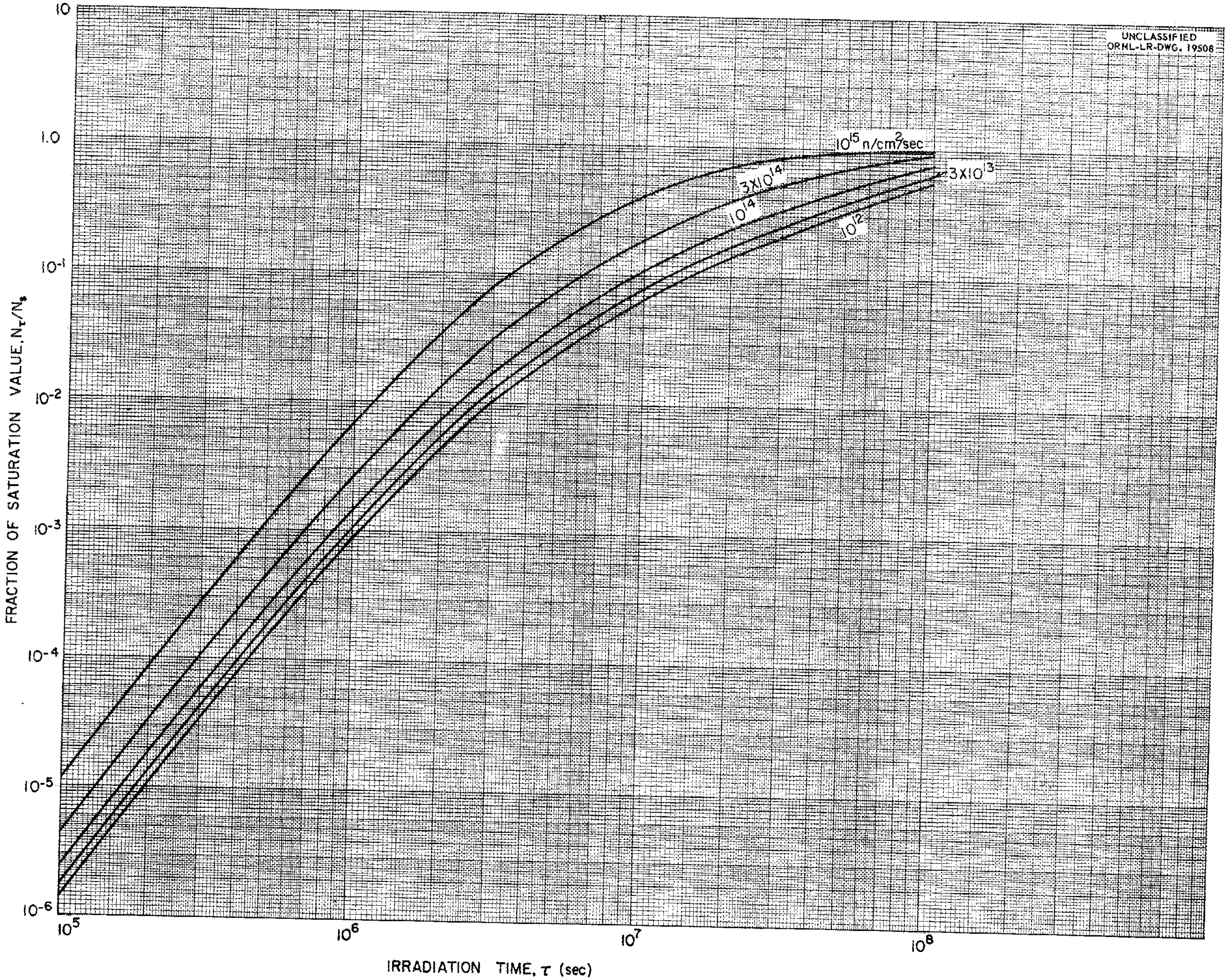

Fig. B-39. Fraction of Saturation Value of 53d Pm^{148*} as a Function of Irradiation Time and Flux.

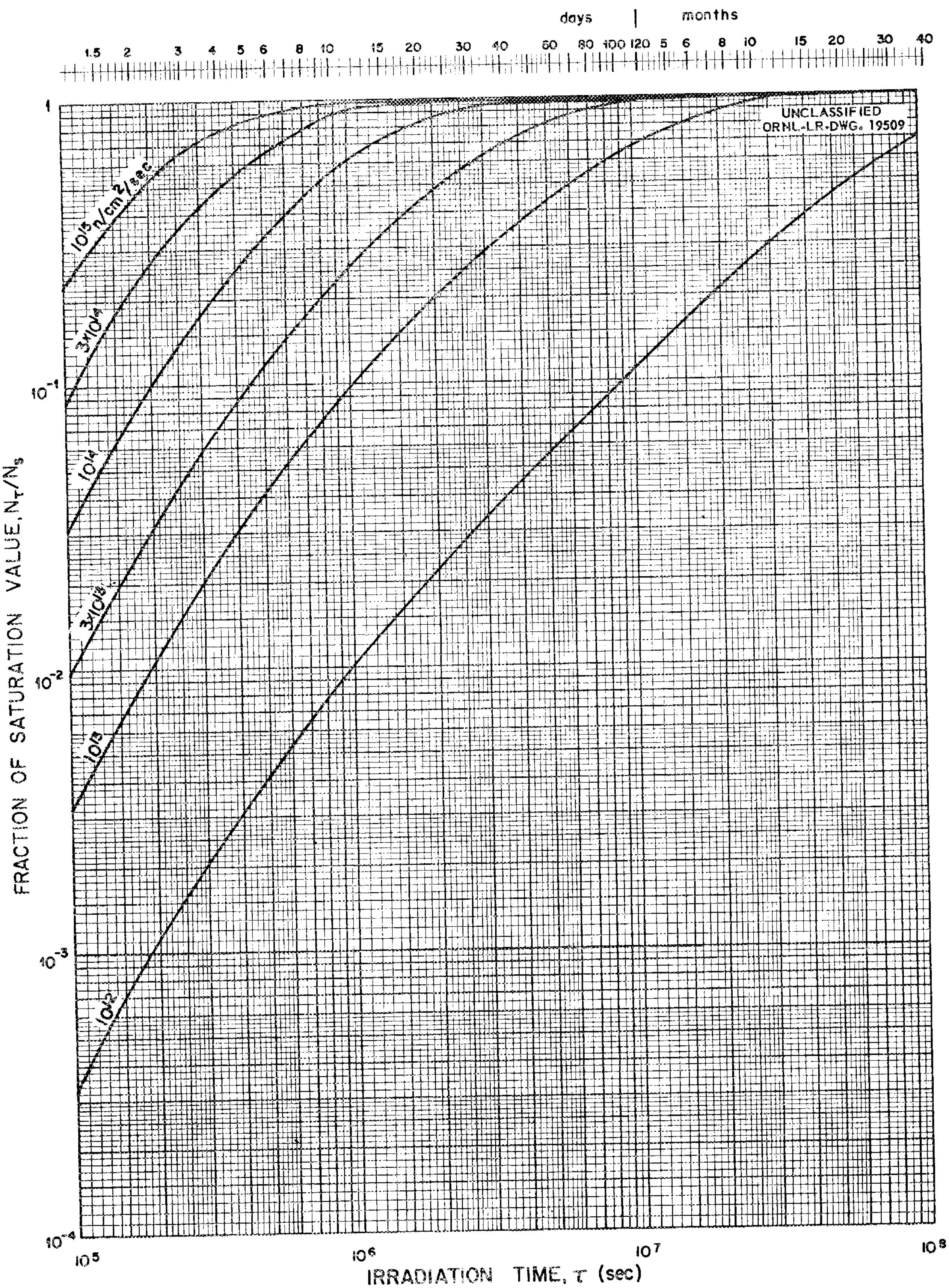

Fig. B-40. Fraction of Saturation Value of 93y Sm^{151} as a Function of Irradiation Time and Flux.

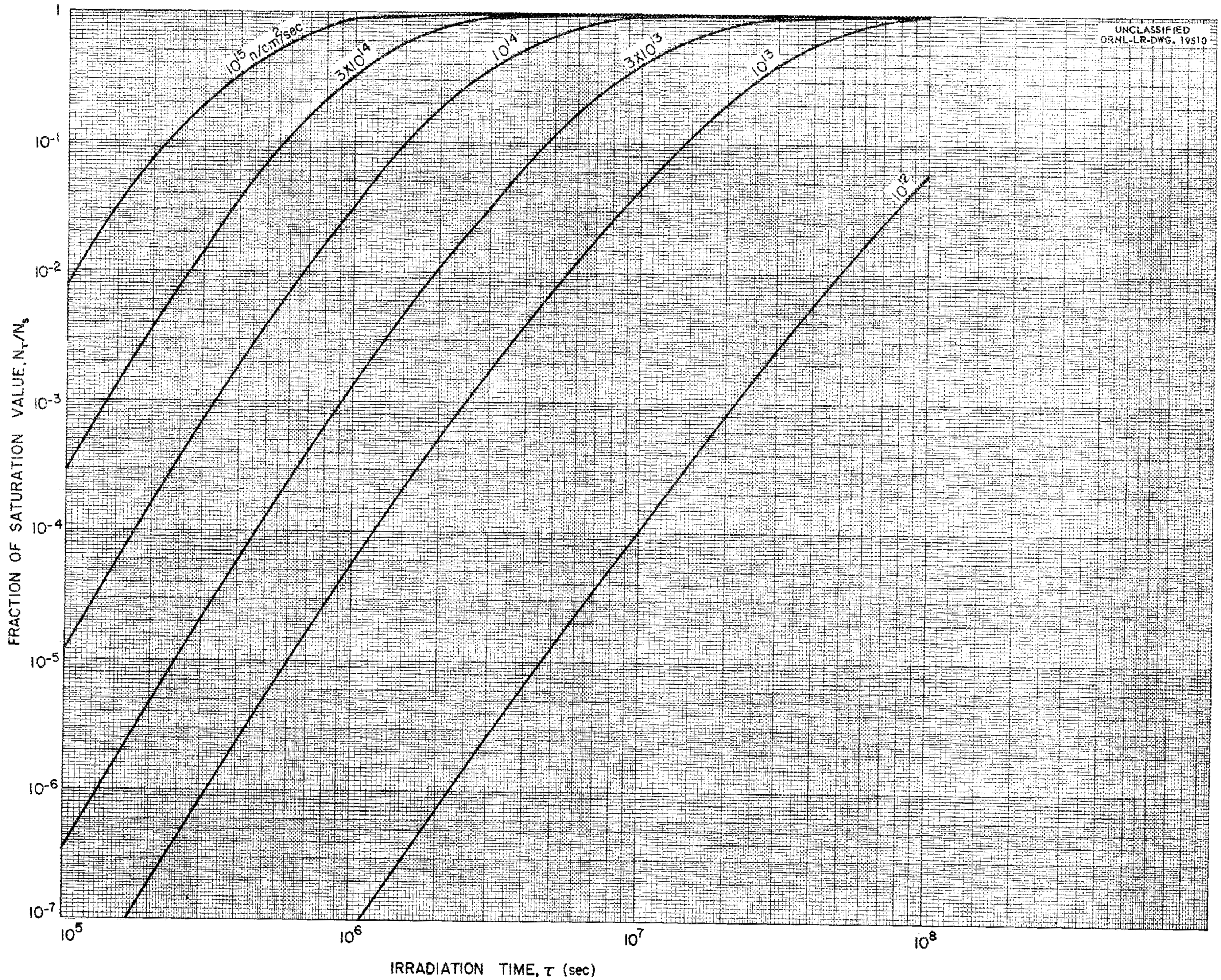

Fig. B-41. Fraction of Saturation Value of 13y Eu^{152*} as a Function of Irradiation Time and Flux.

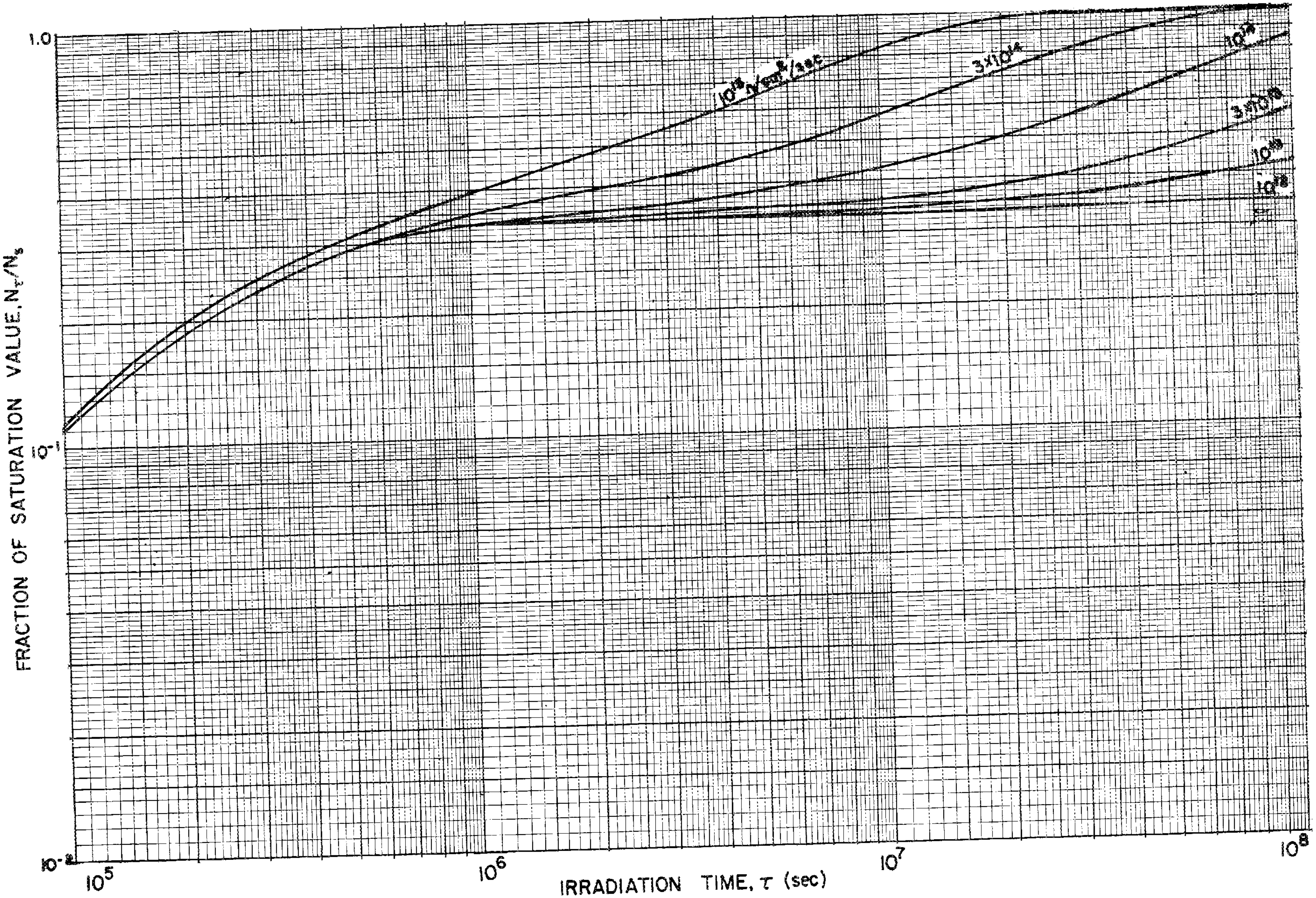

Fig. B-42. Fraction of Saturation Value of **47h Sm^{153}** as a Function of Irradiation Time and Flux.

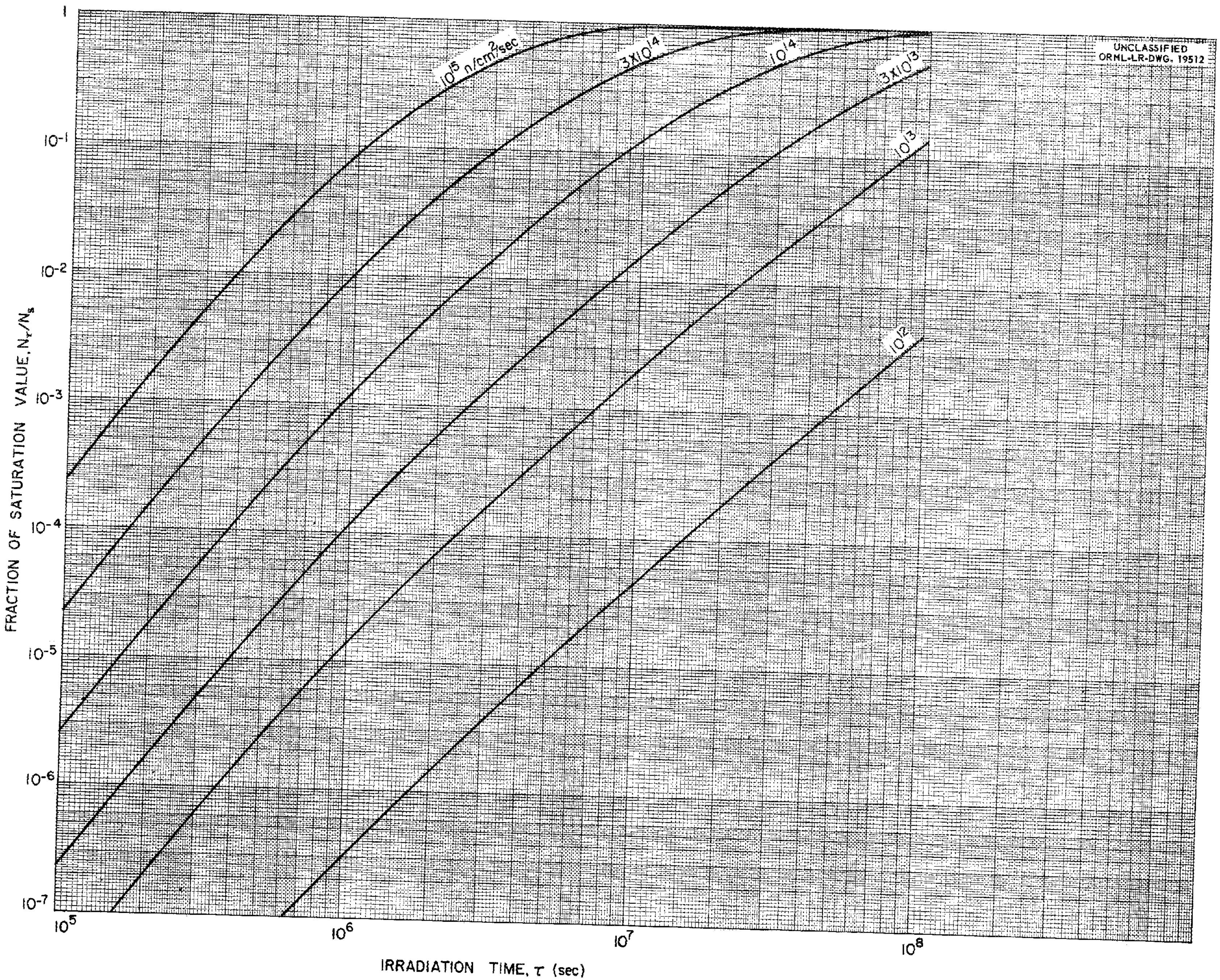

Fig. B-43. Fraction of Saturation Value of 16y Eu^{154} as a Function of Irradiation Time and Flux.

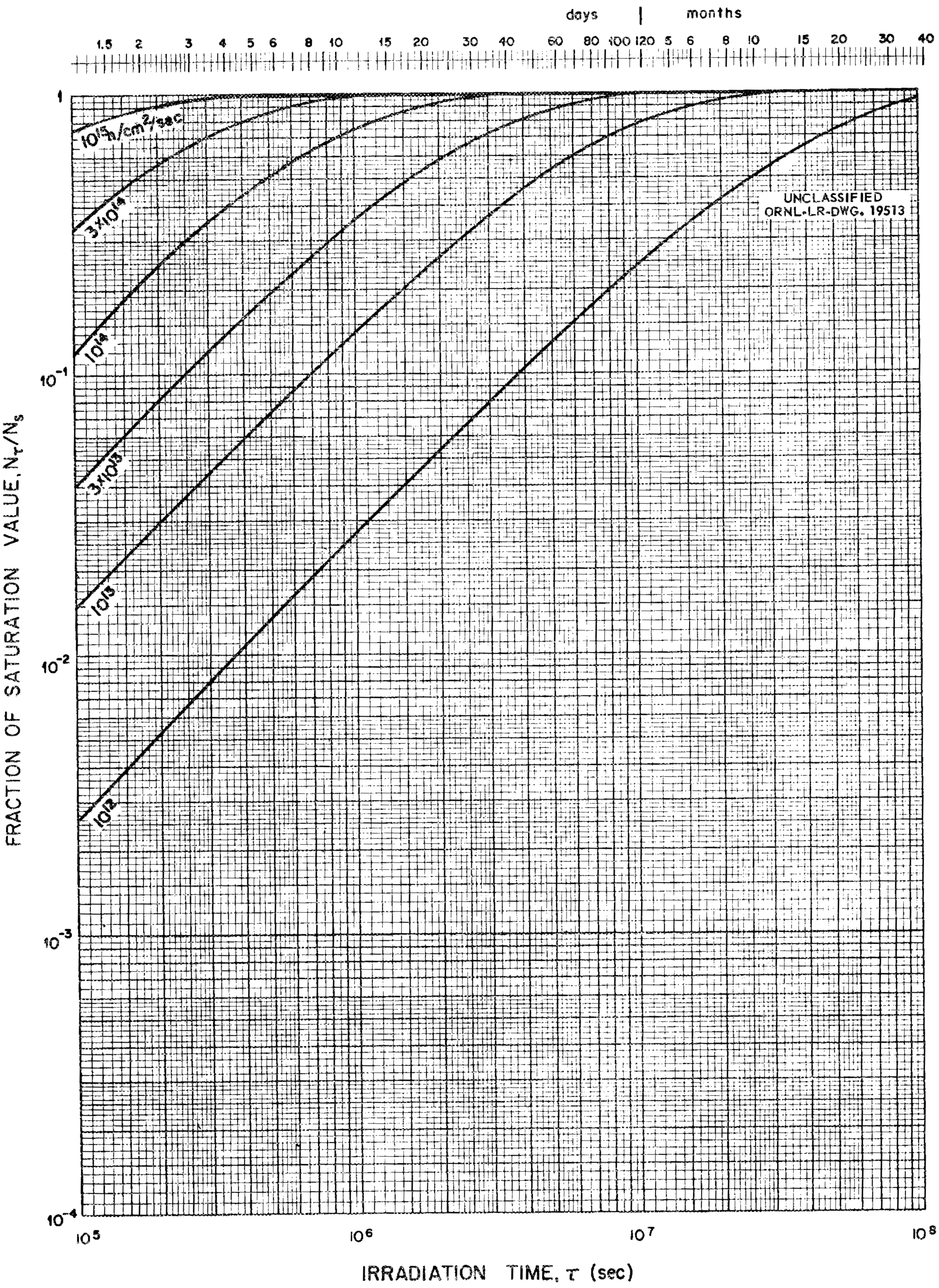

Fig. B-44. Fraction of Saturation Value of 1.7y Eu^{155} as a Function of Irradiation Time and Flux.

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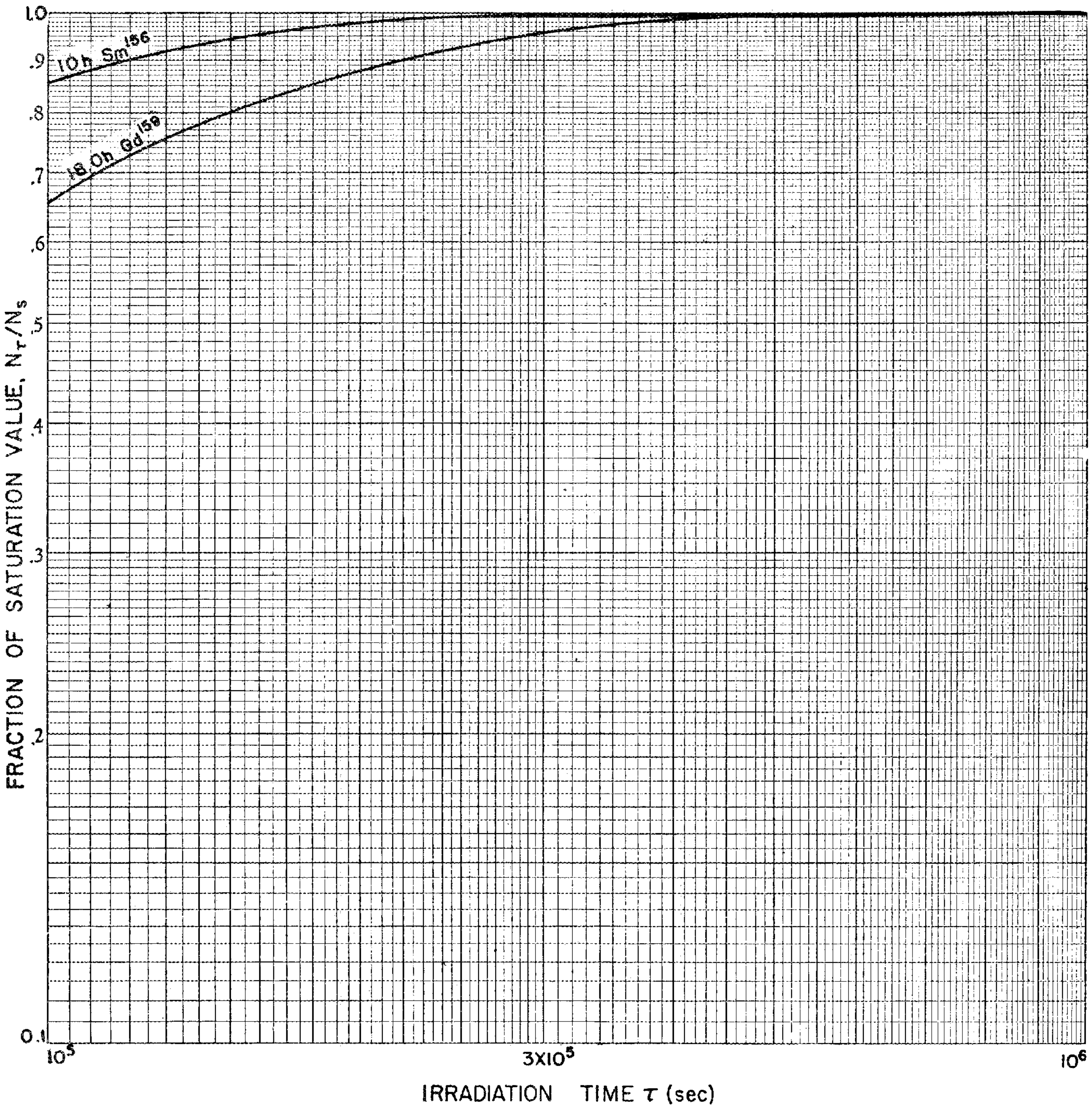

Fig. B-45. Fraction of Saturation Value of Various Radioactive Fission Products as a Function of Irradiation Time.

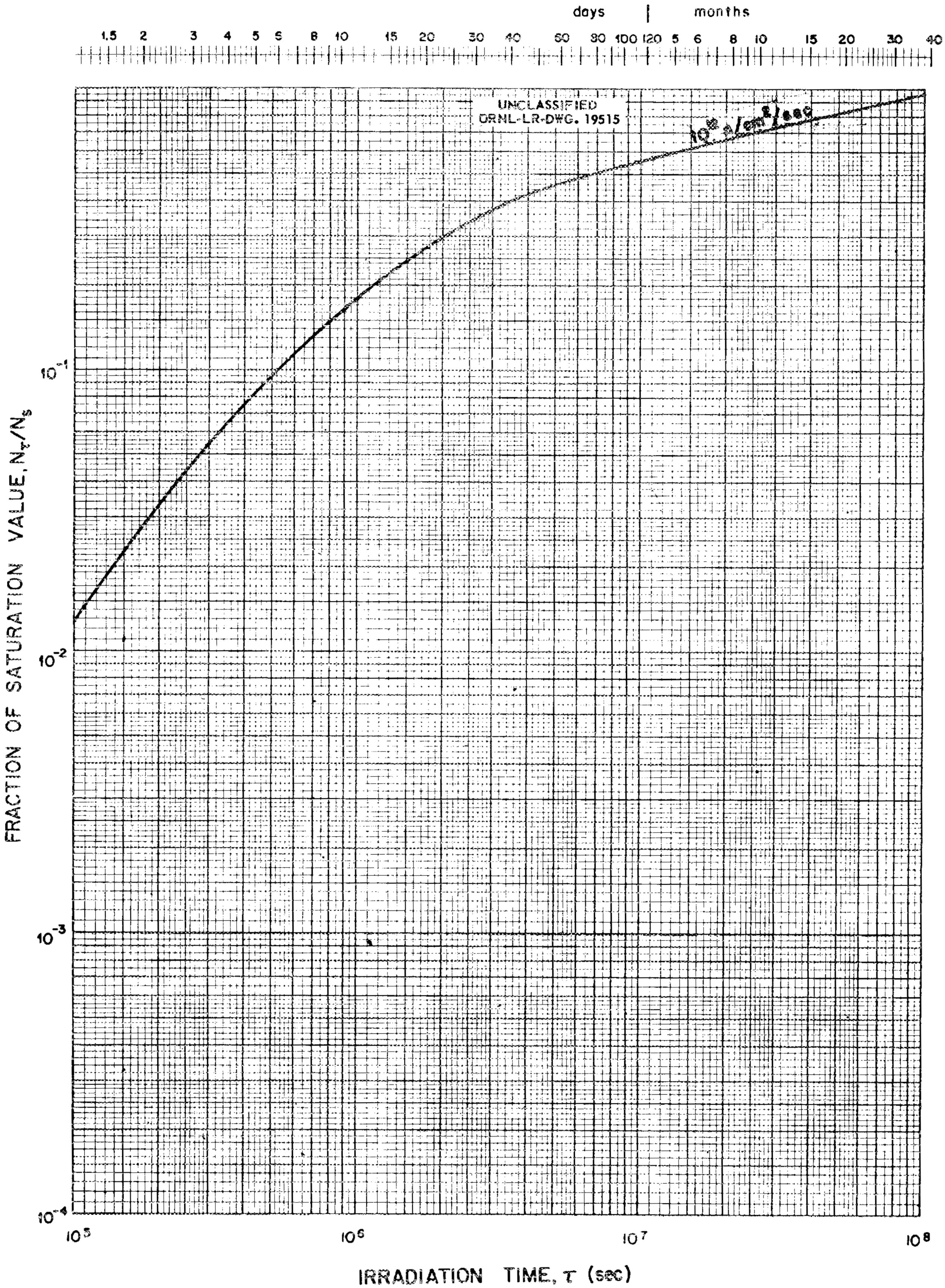

Fig. B-46. Fraction of Saturation Value of 15.4d Eu^{156} as a Function of Irradiation Time and Flux.

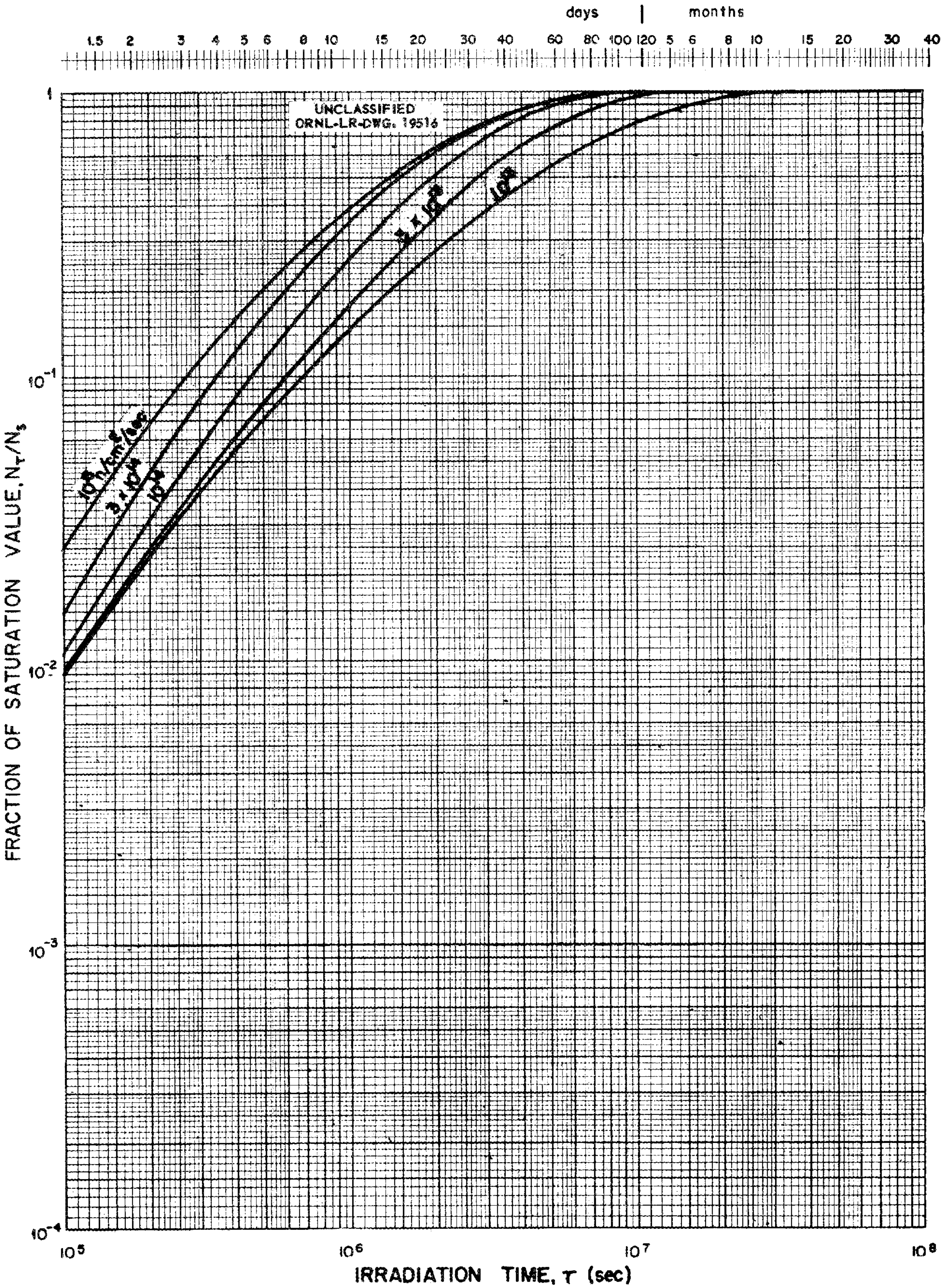

Fig. B-46a. Fraction of Saturation Value of 15.4d Eu^{156} as a Function of Irradiation Time and Flux.

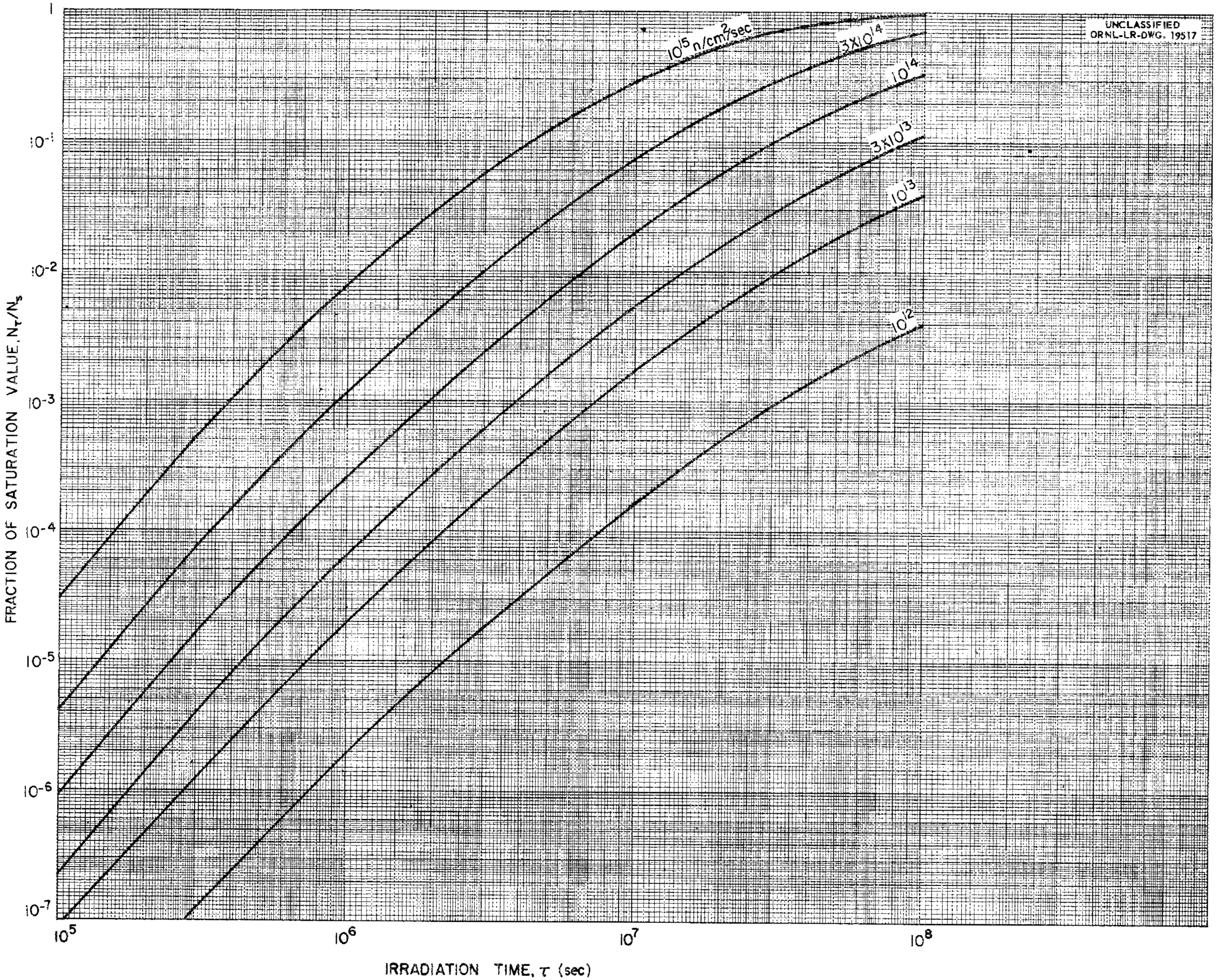

Fig. B-47. Fraction of Saturation Value of 73.5d Tb^{160*} as a Function of Irradiation Time and Flux.

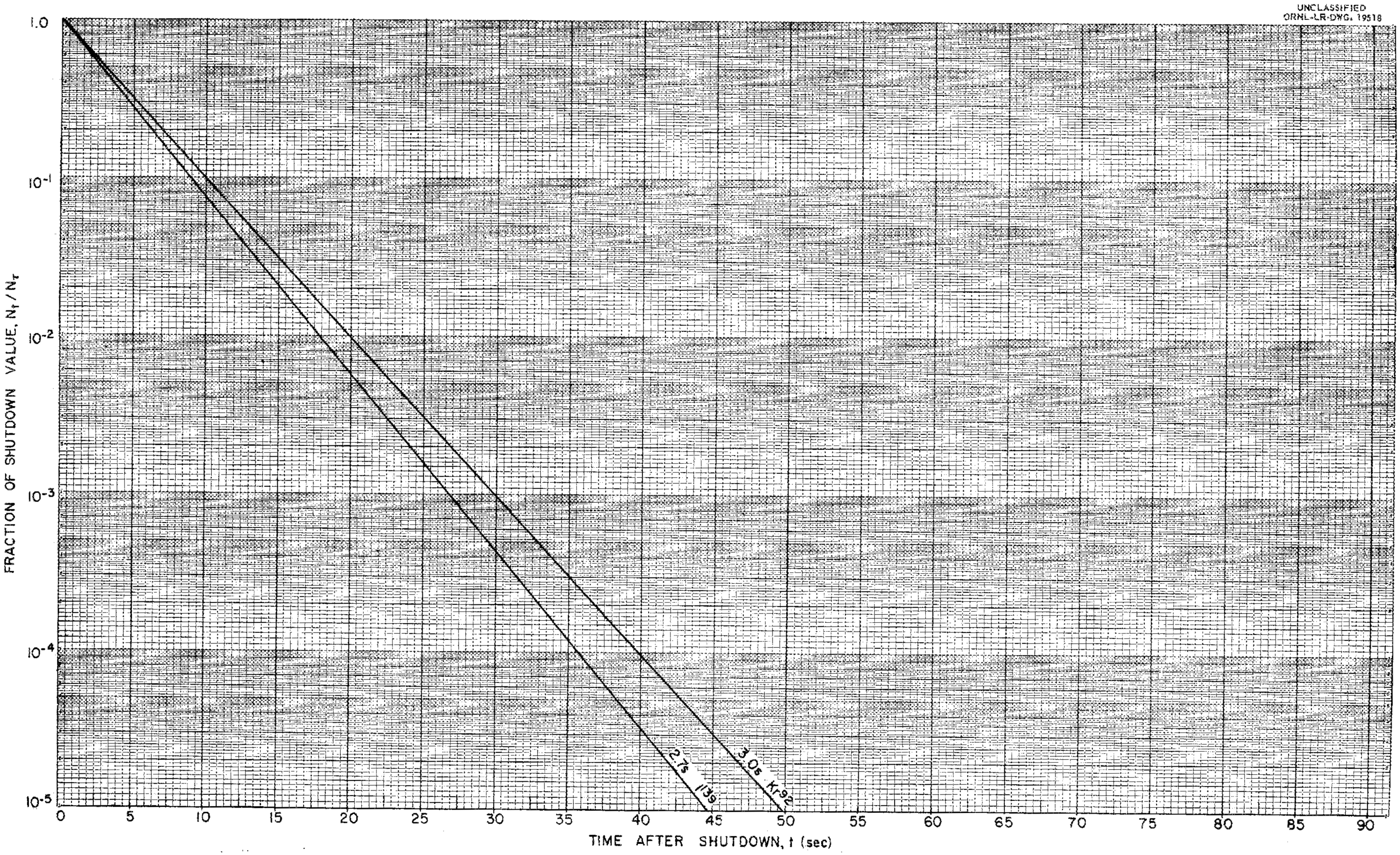

Fig. C-1. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

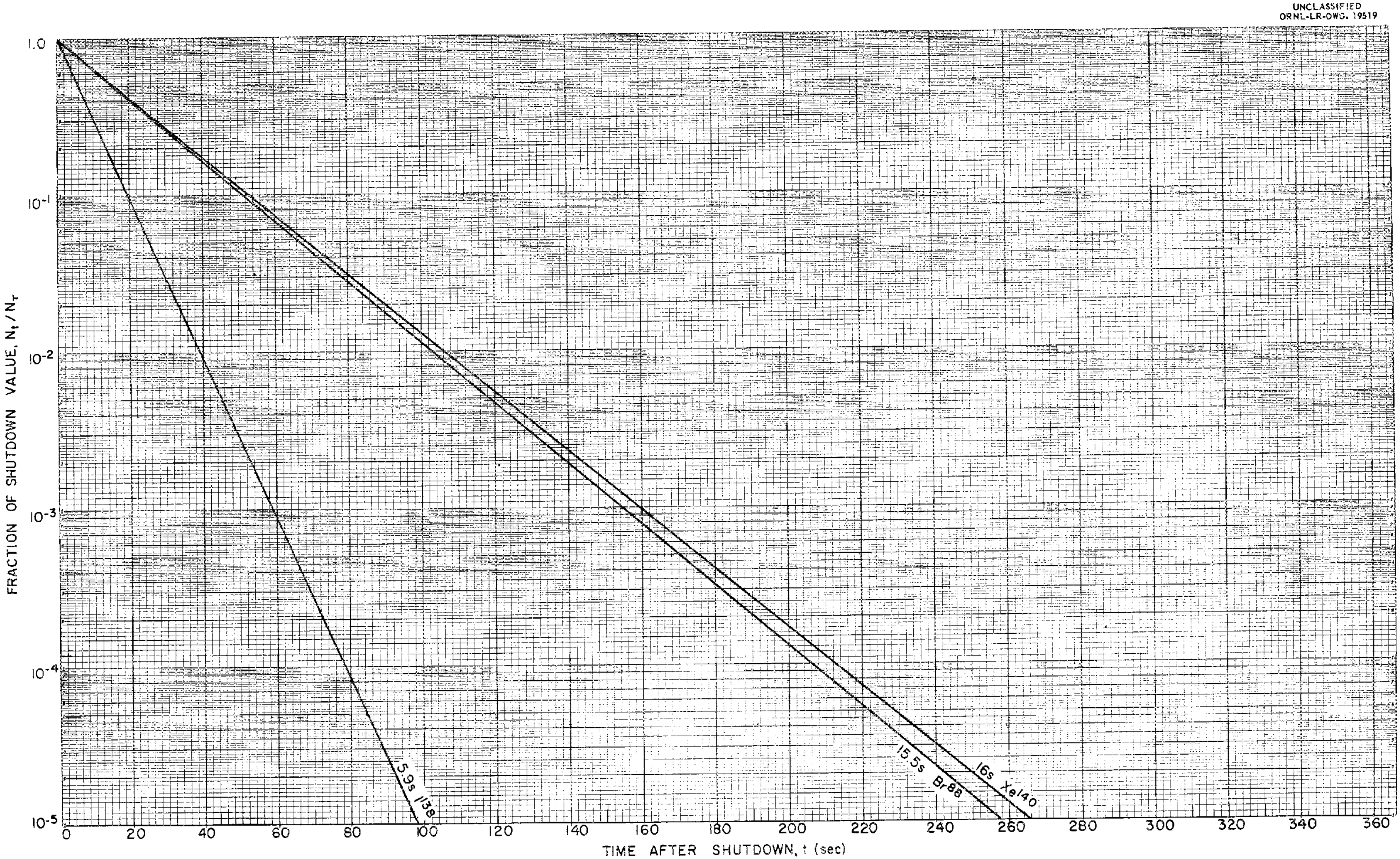

Fig. C-2. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

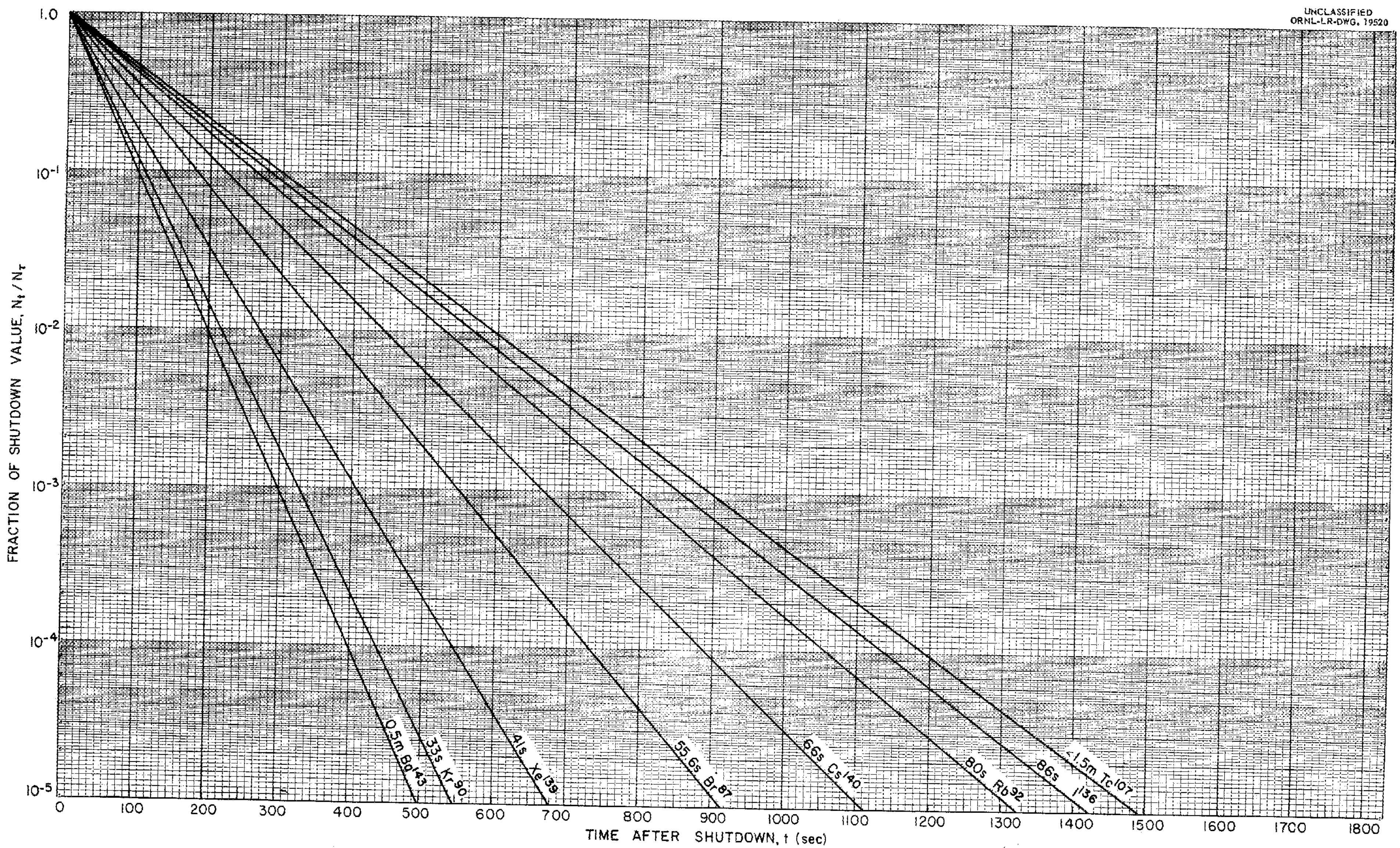

Fig. C-3. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

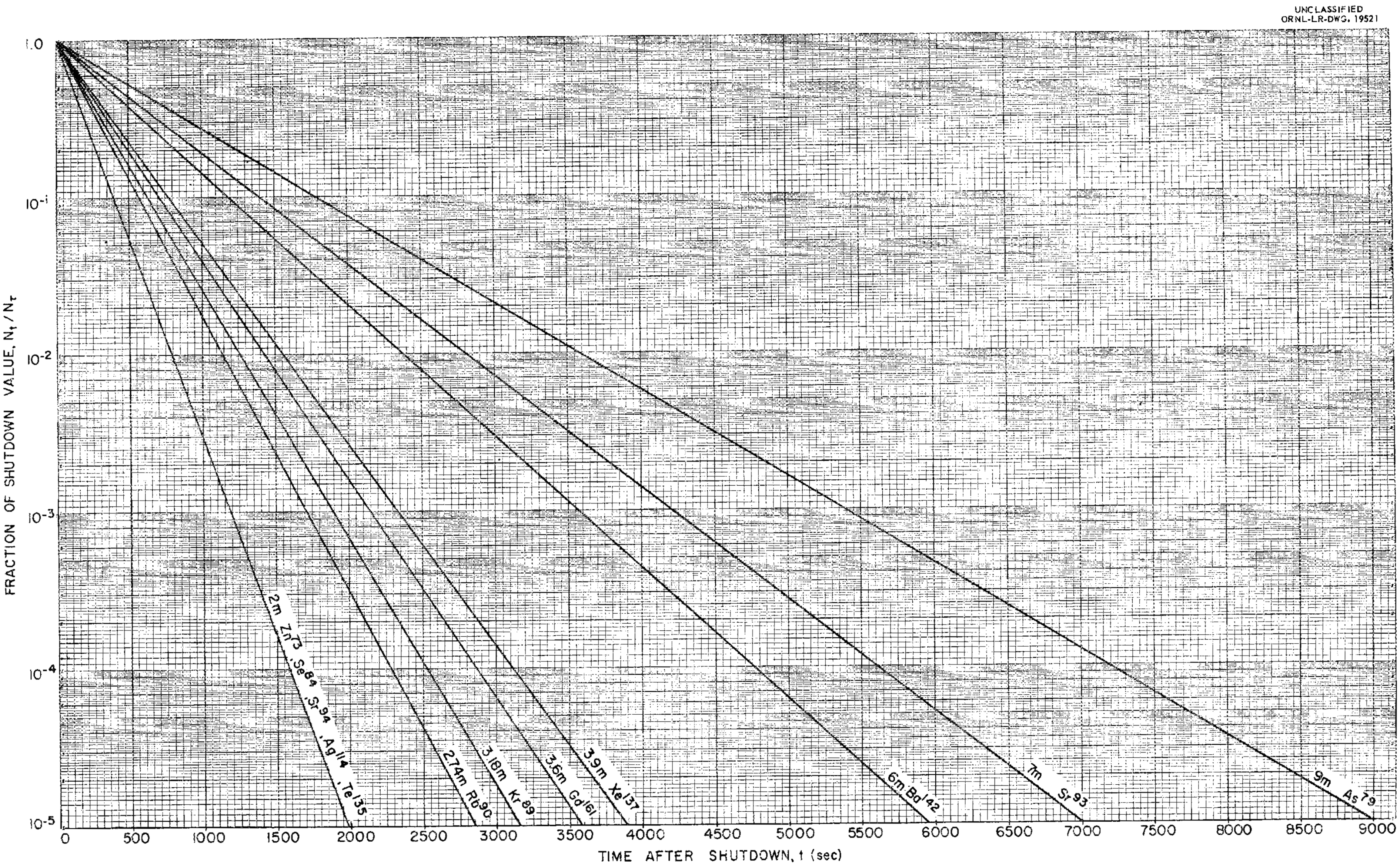

Fig. C-4. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

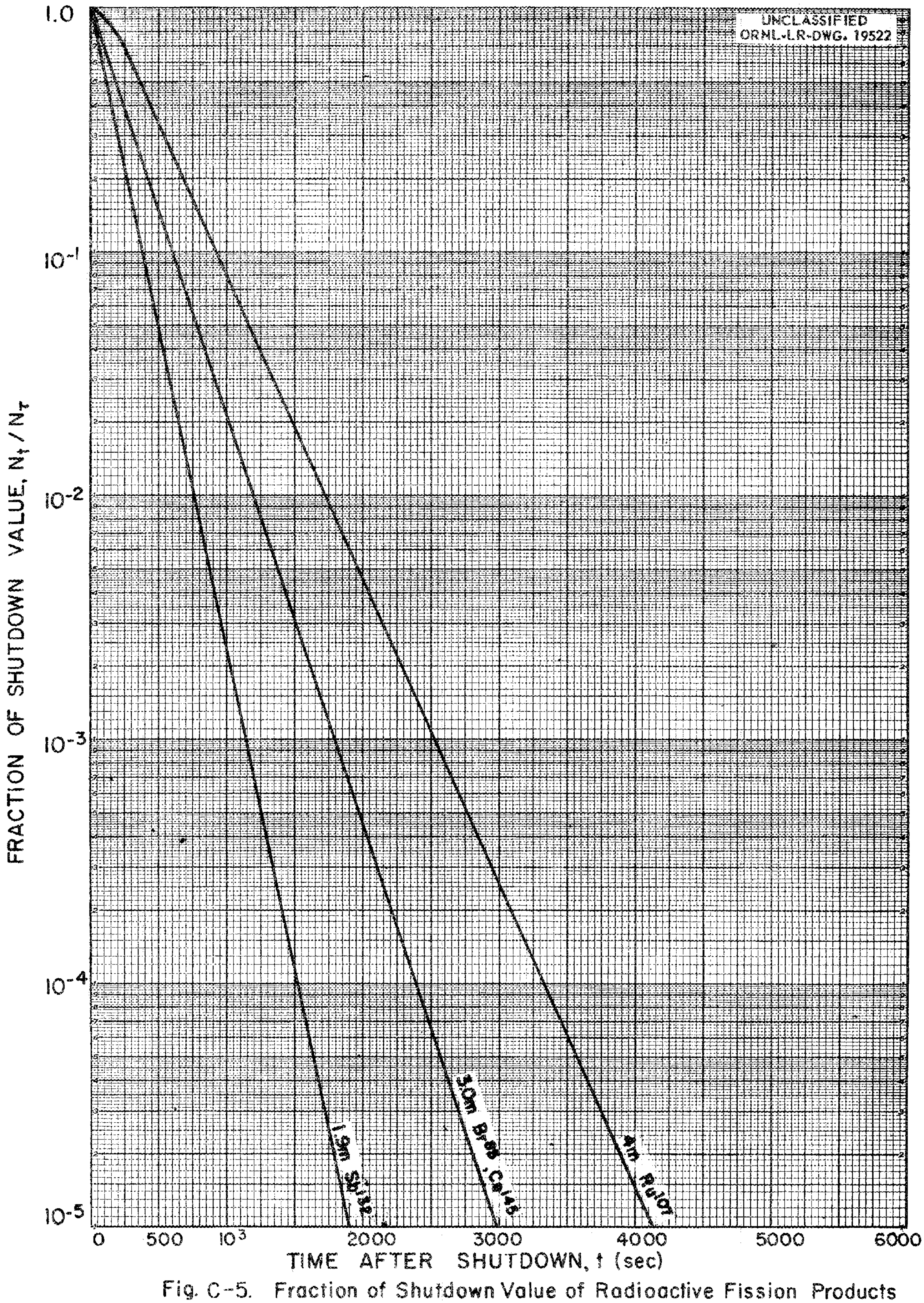

Fig. C-5. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

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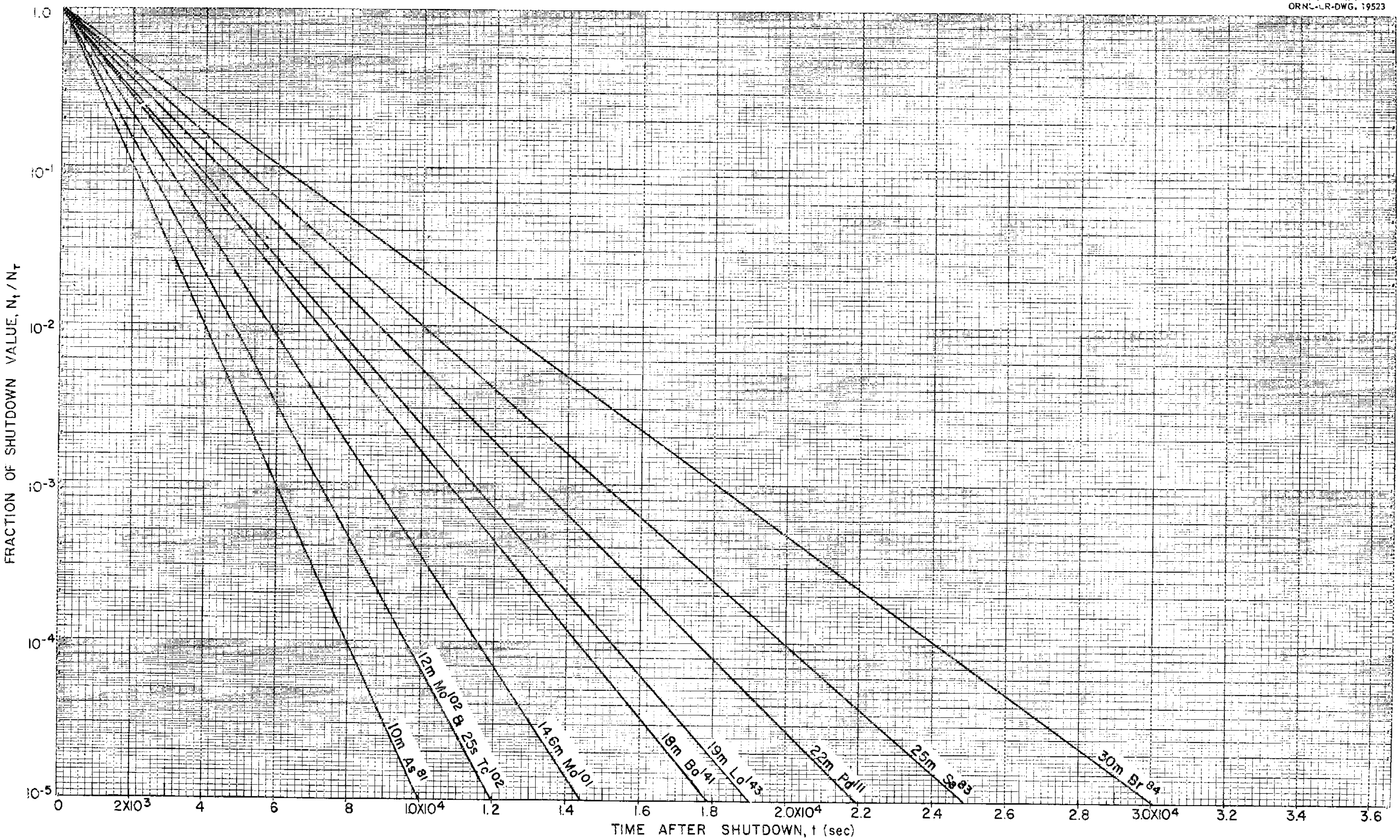

Fig. C-6. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

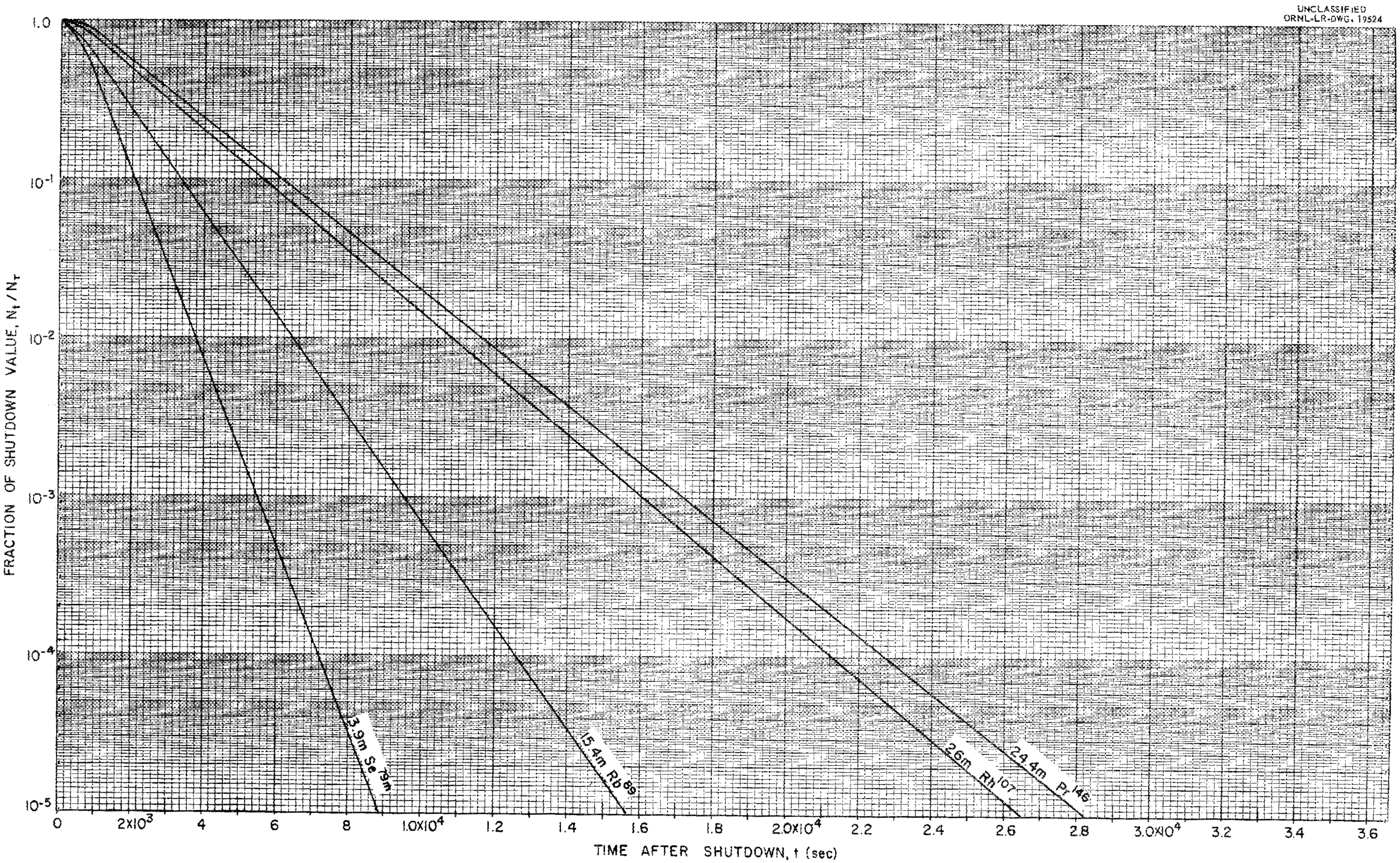

Fig. C-7. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

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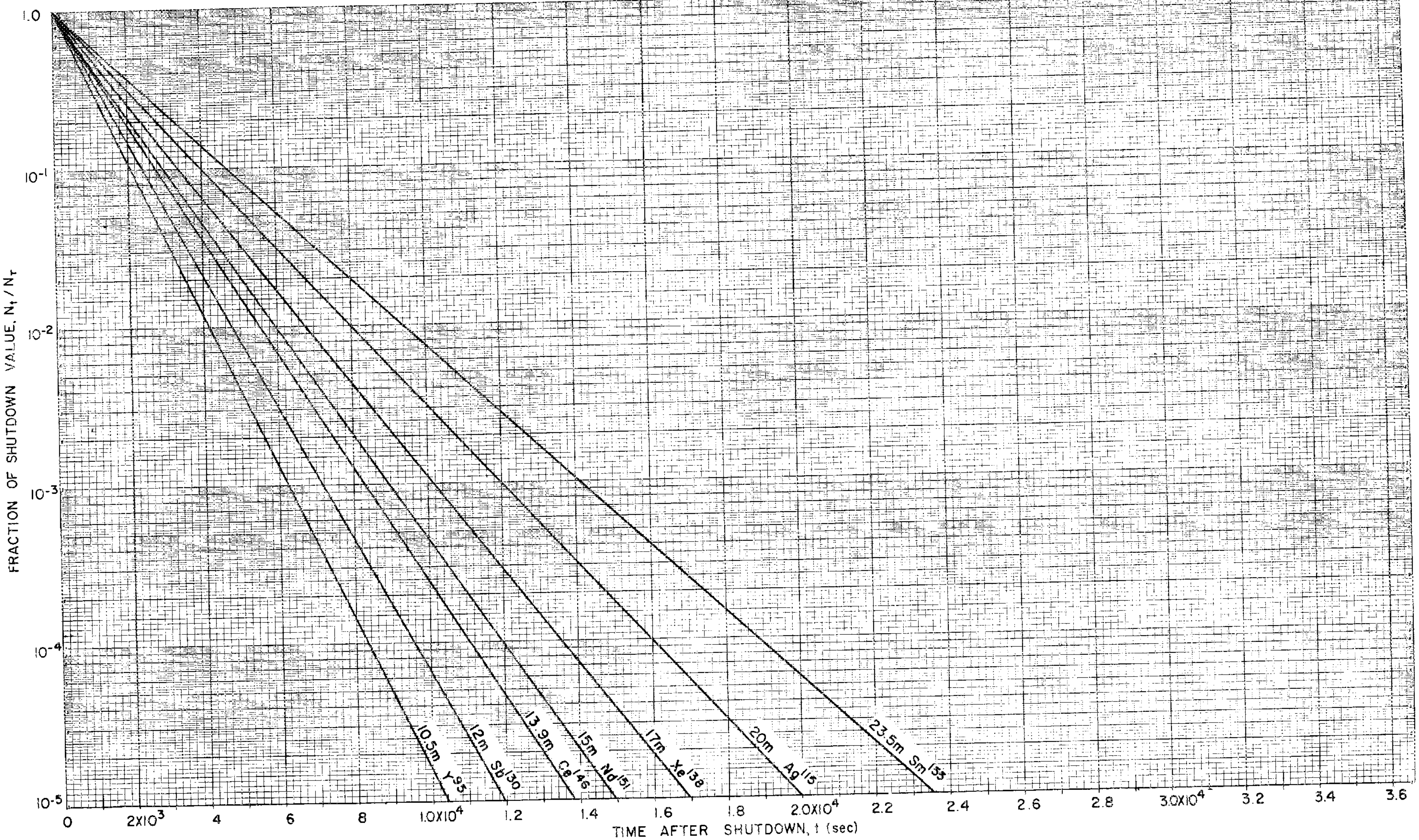

Fig. C-8. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

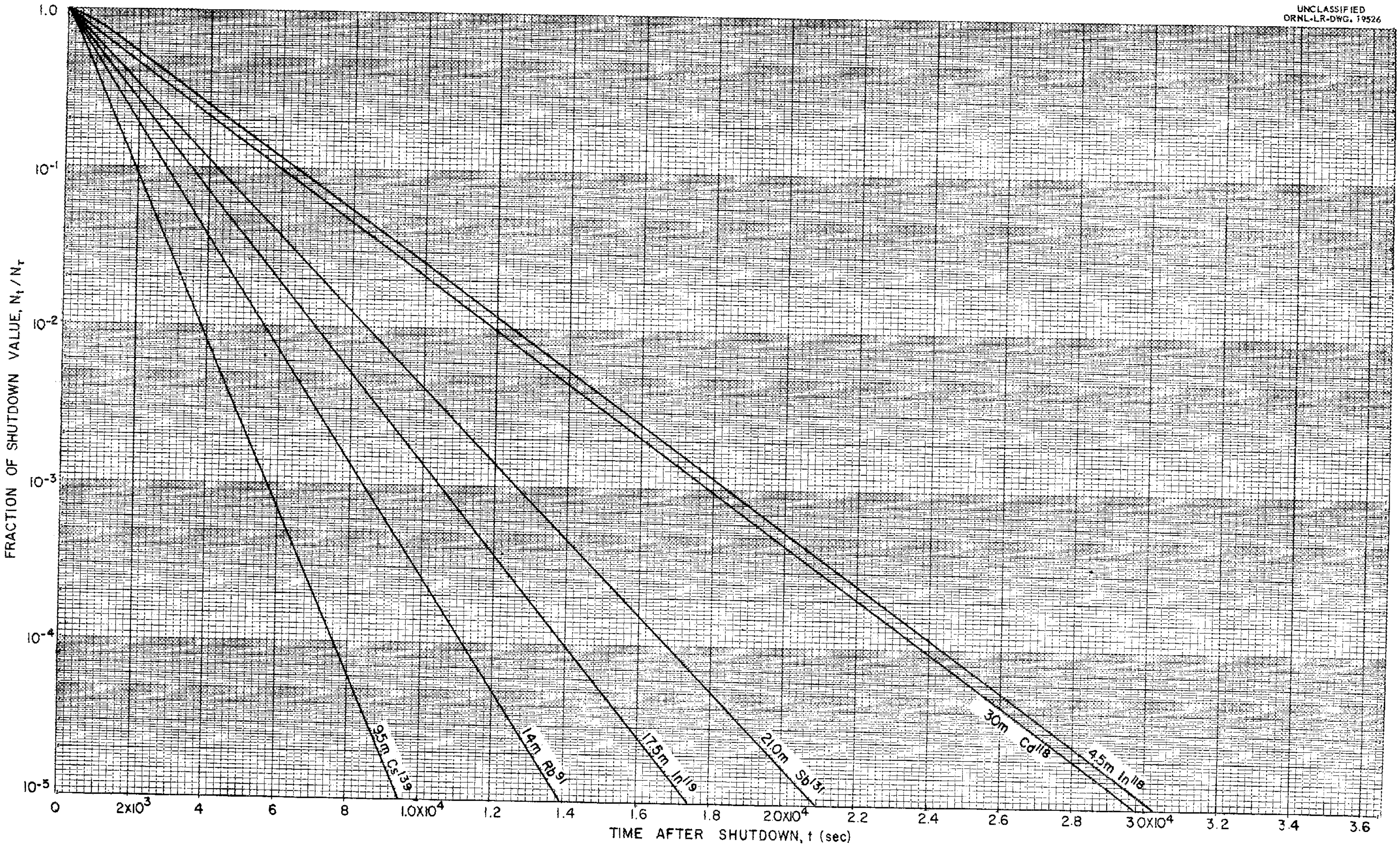

Fig. C-9. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

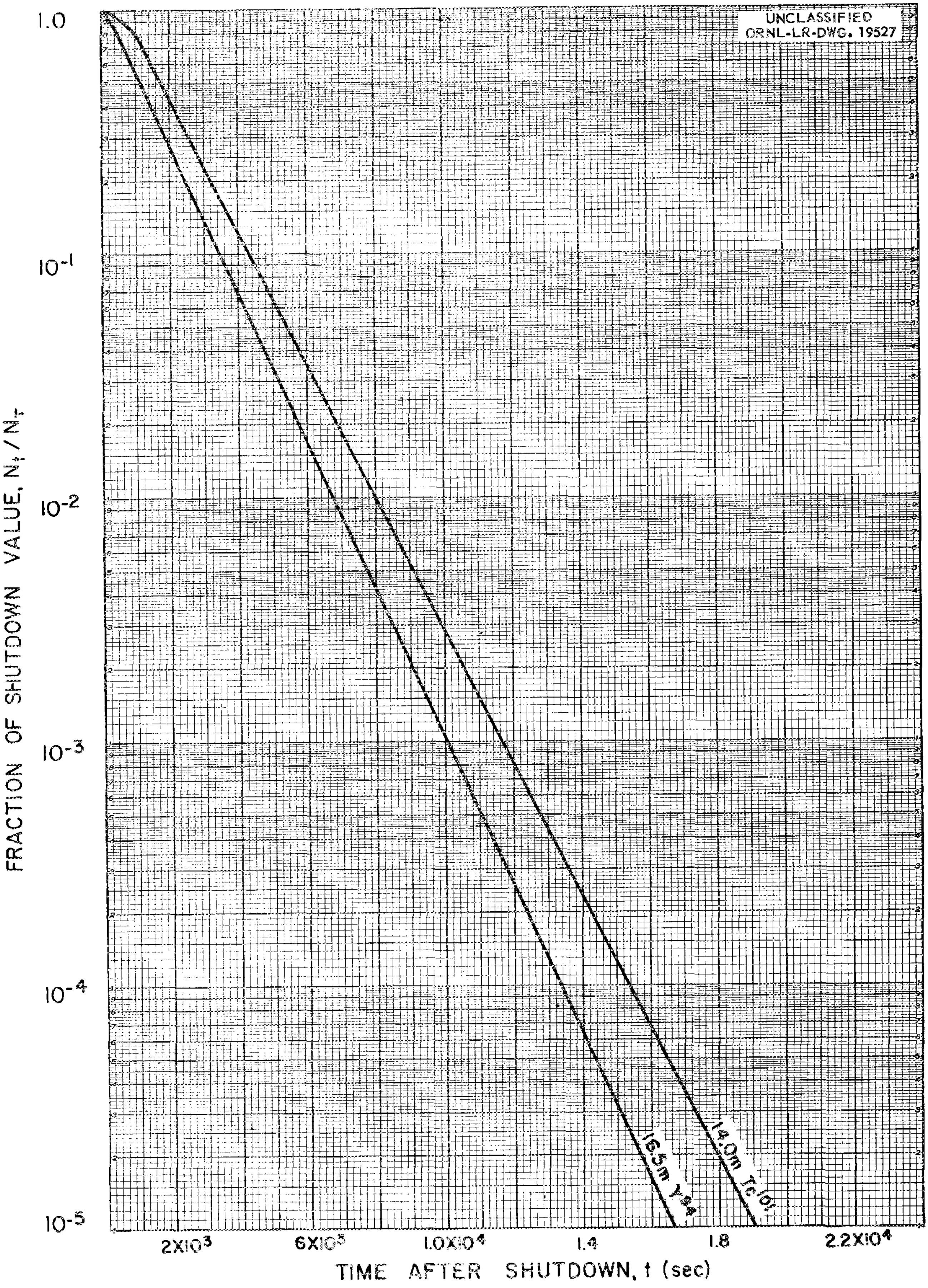

Fig. C-9a. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

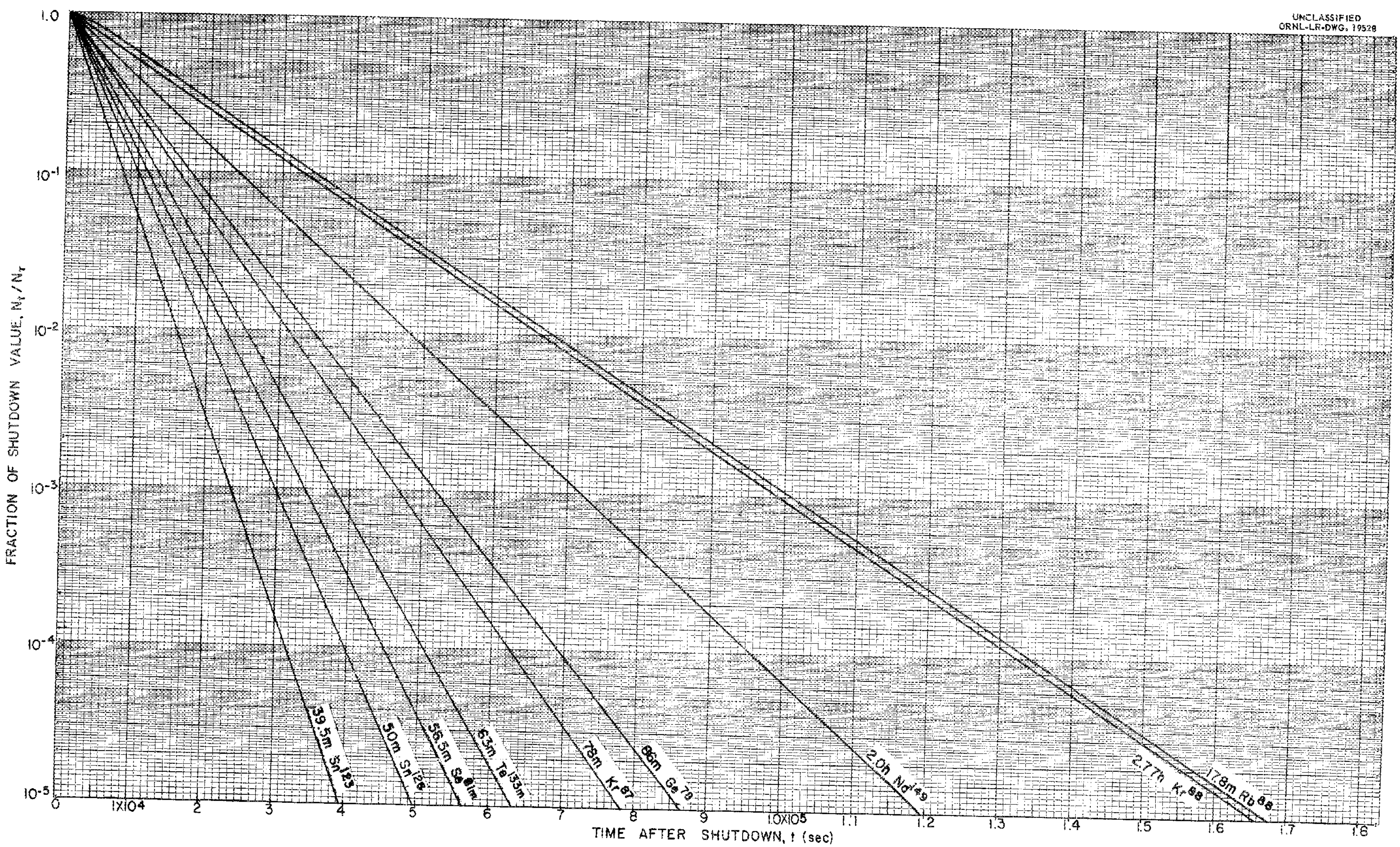

Fig. C-10. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

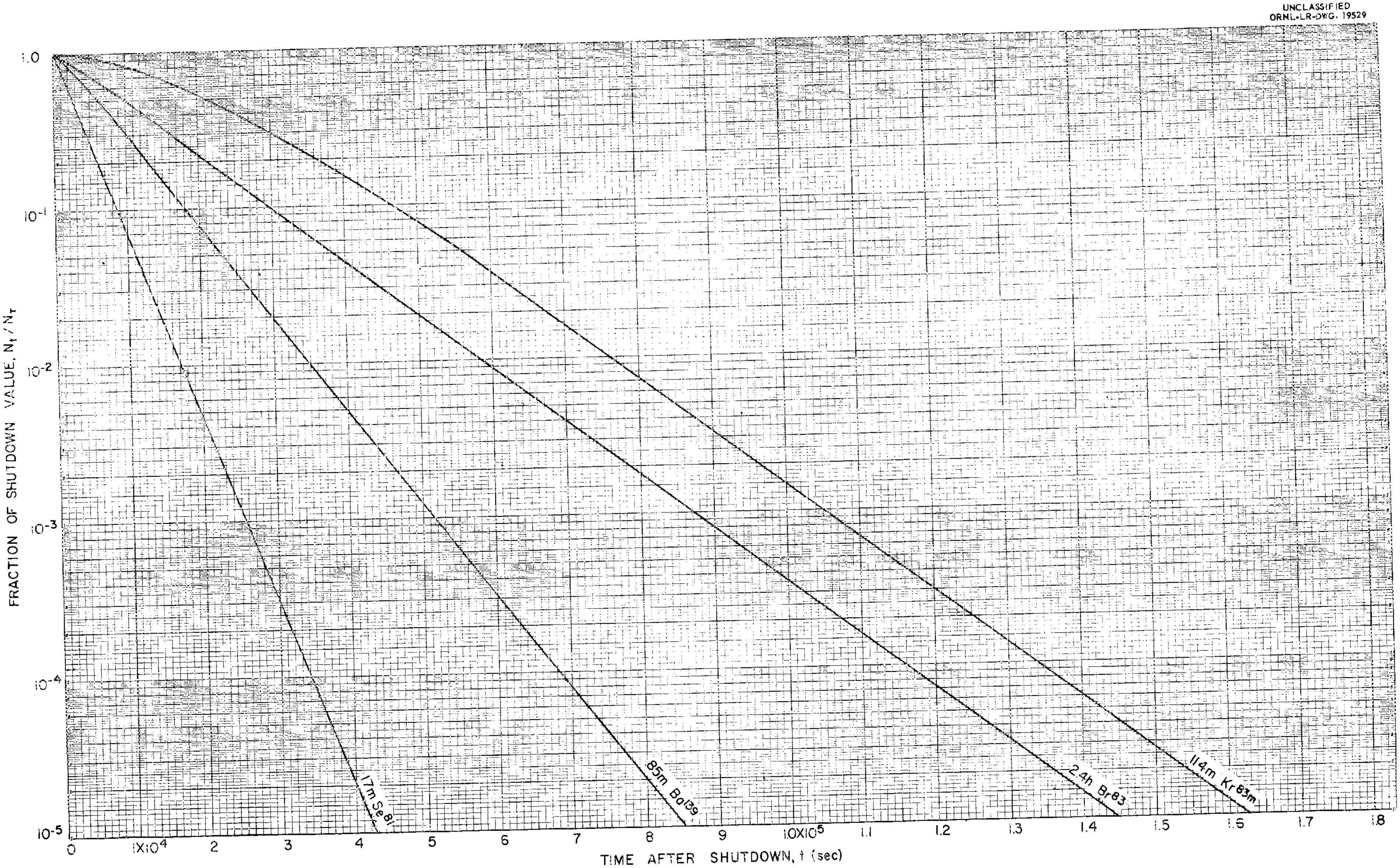

Fig. C-11. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

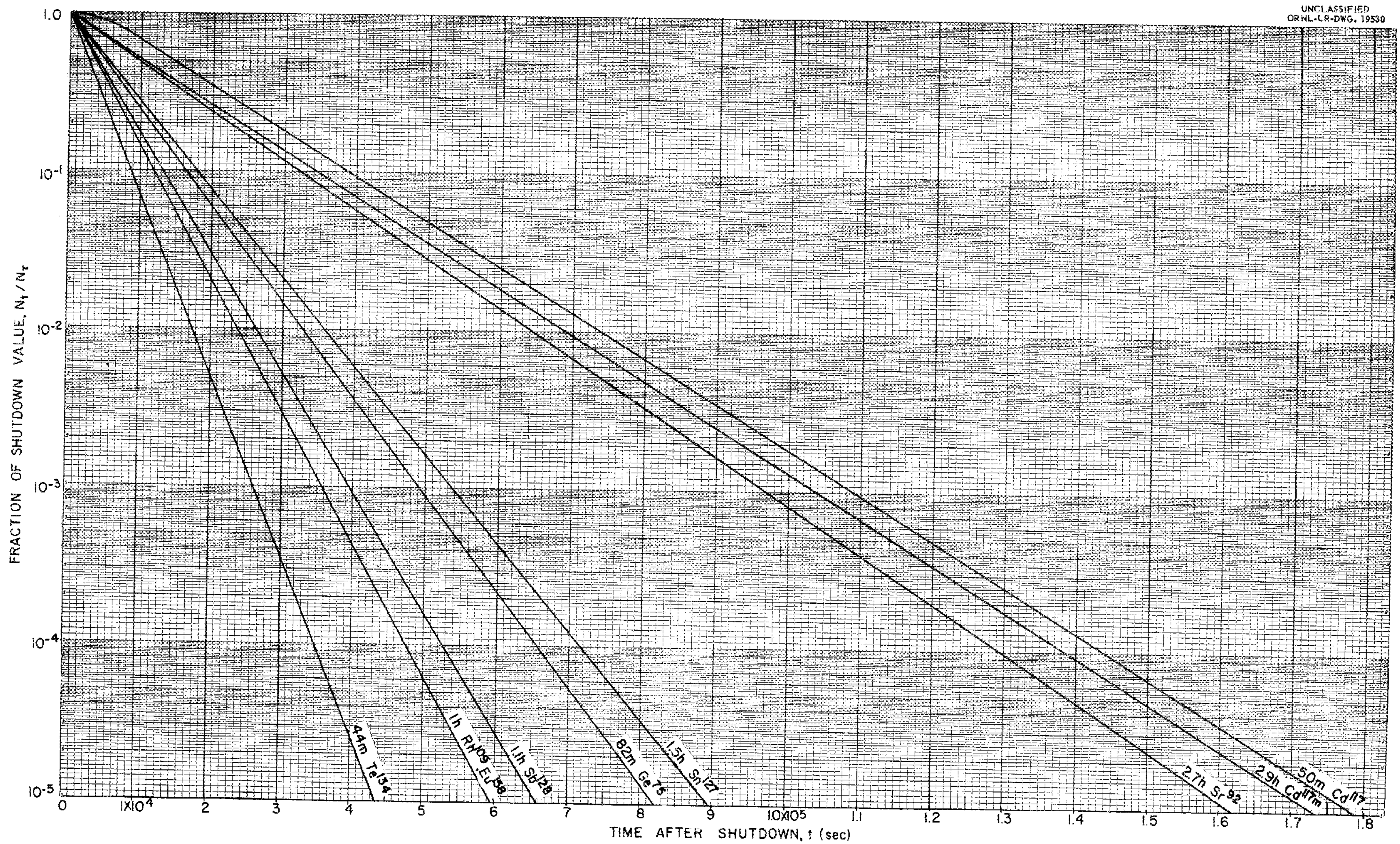

Fig. C-12. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

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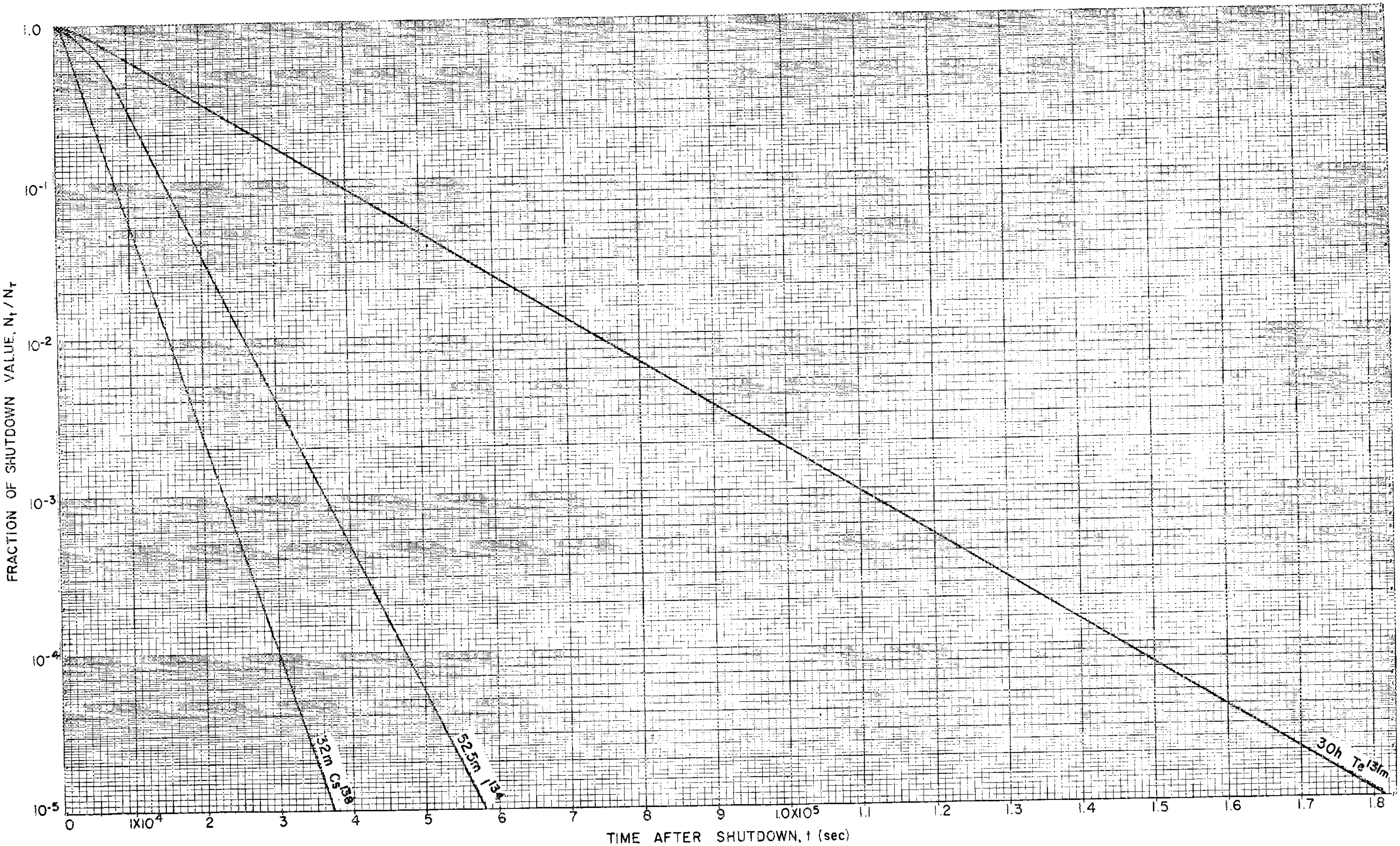

Fig. C-13. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

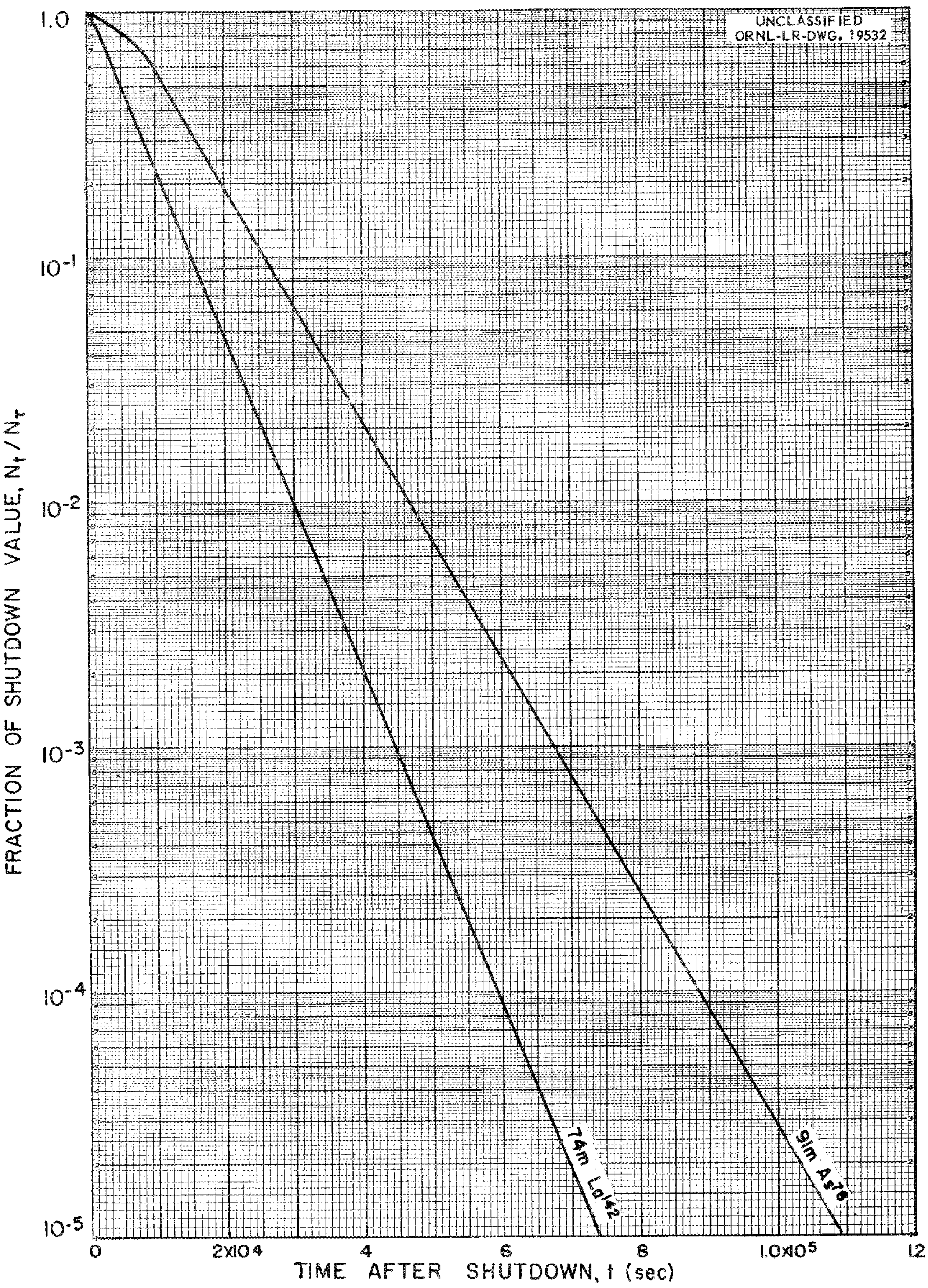

Fig. C-14. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

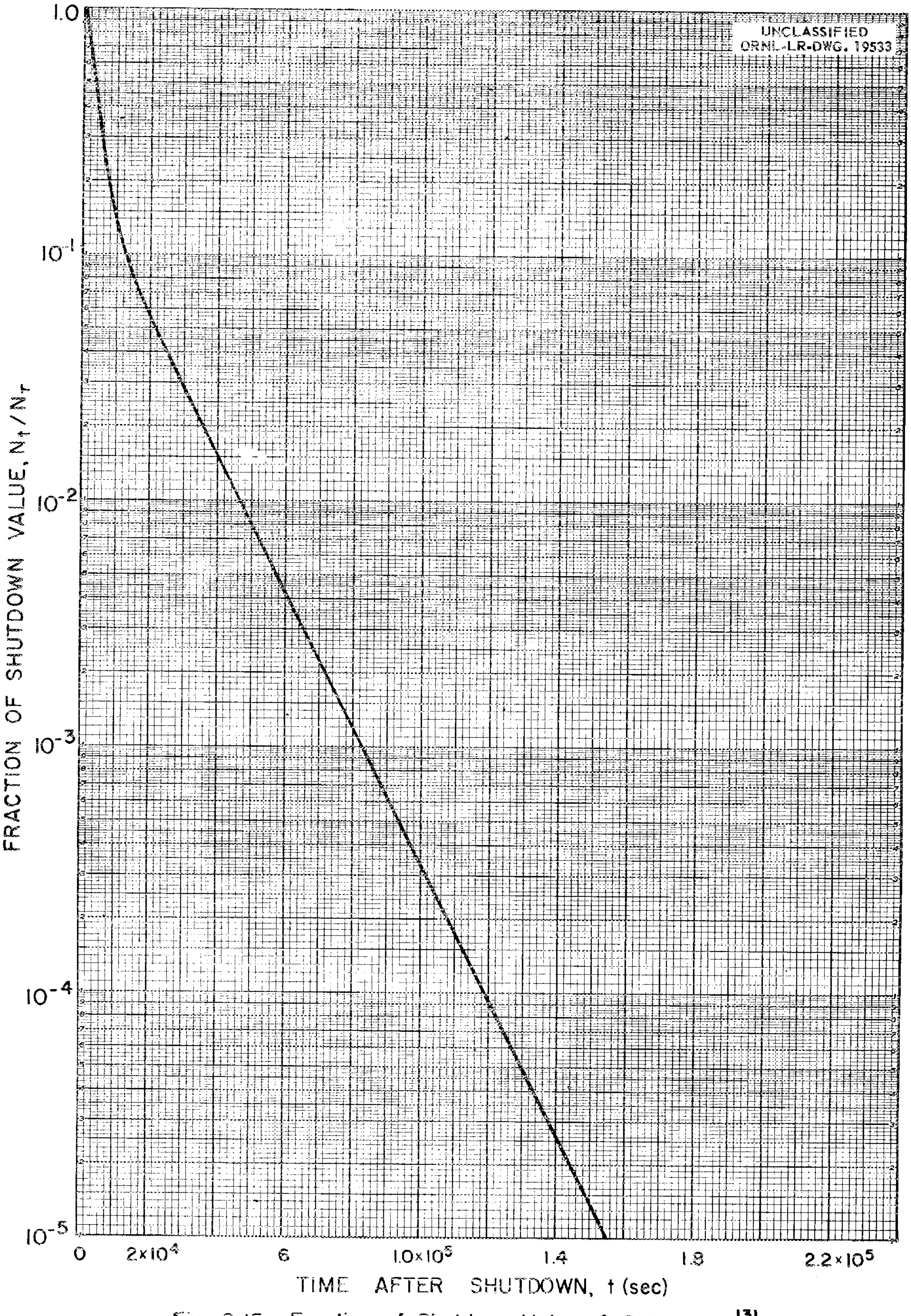

Fig. C-15. Fraction of Shutdown Value of 24.8m Te^{131} Remaining at Various Times After Shutdown.

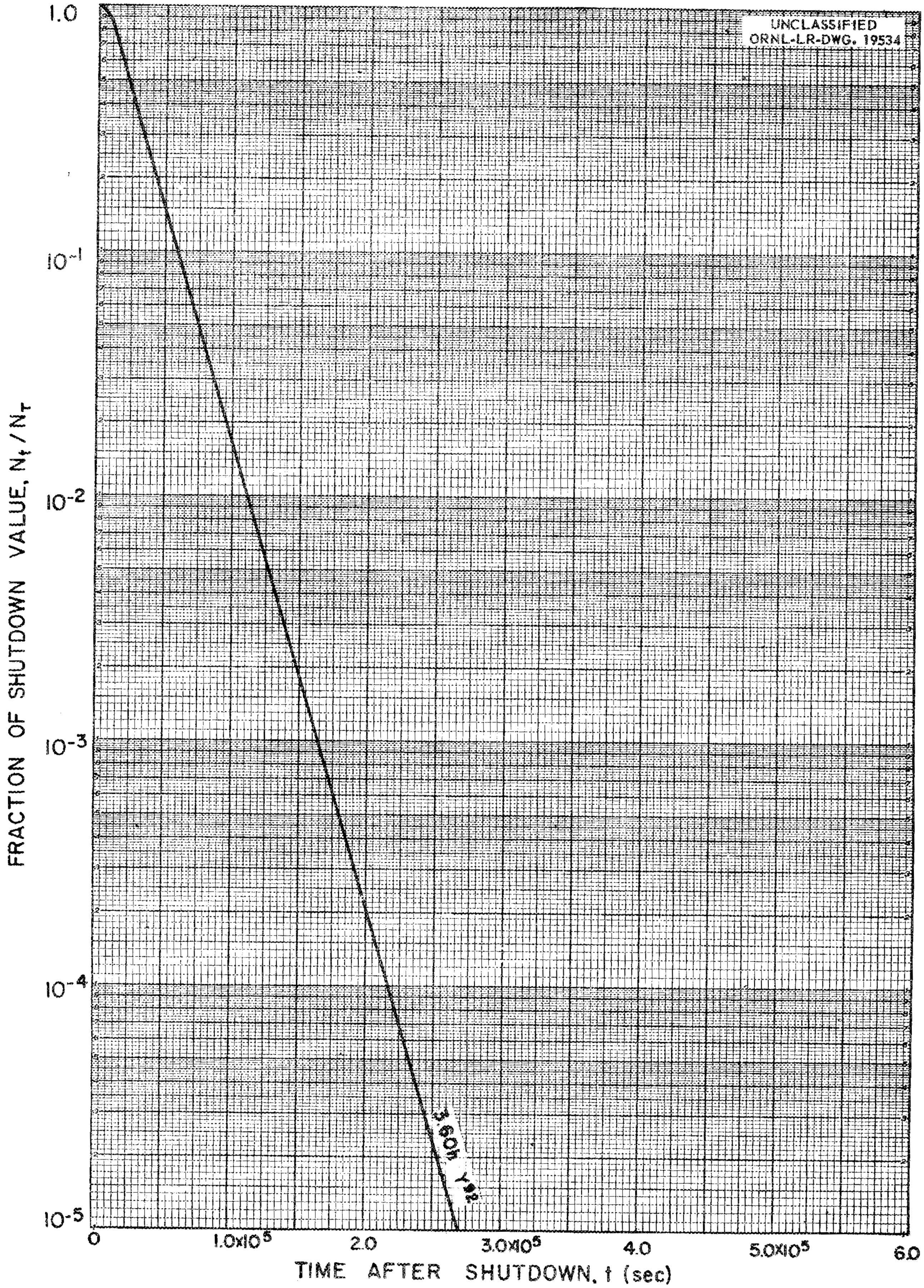

Fig. C-16. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

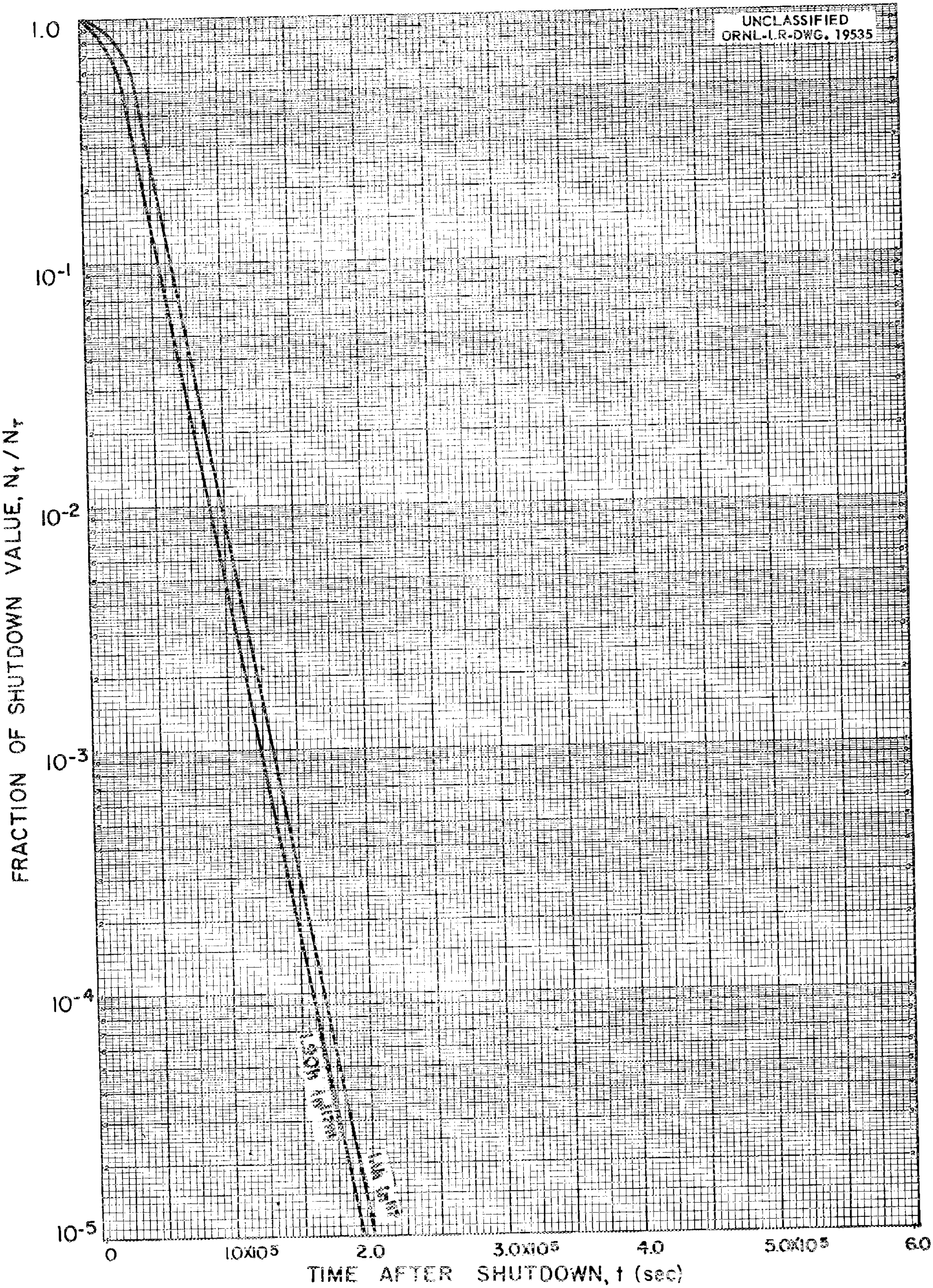

Fig. C-17. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

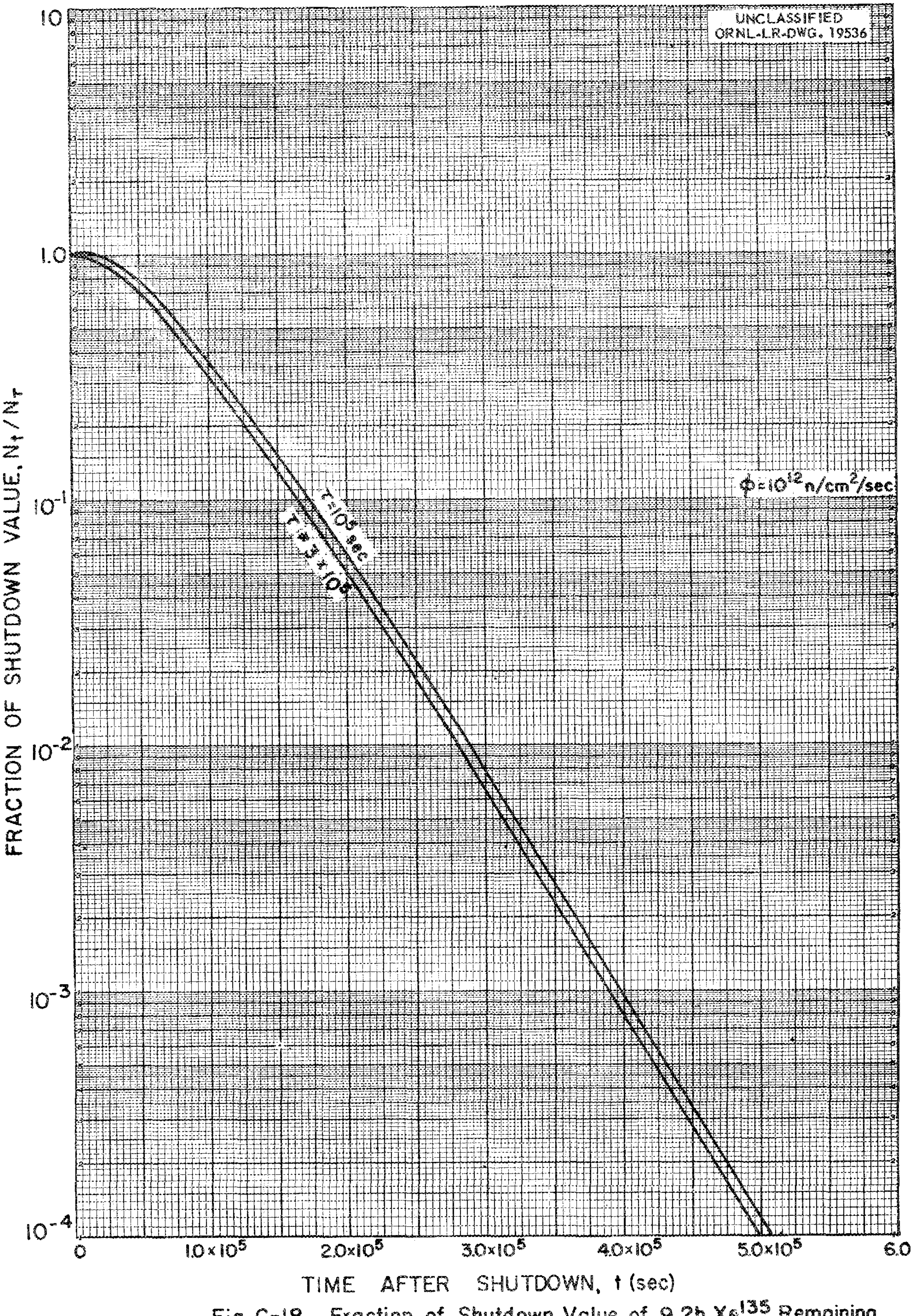

Fig. C-18. Fraction of Shutdown Value of 9.2h Xe^{135} Remaining at Various Times After Shutdown.

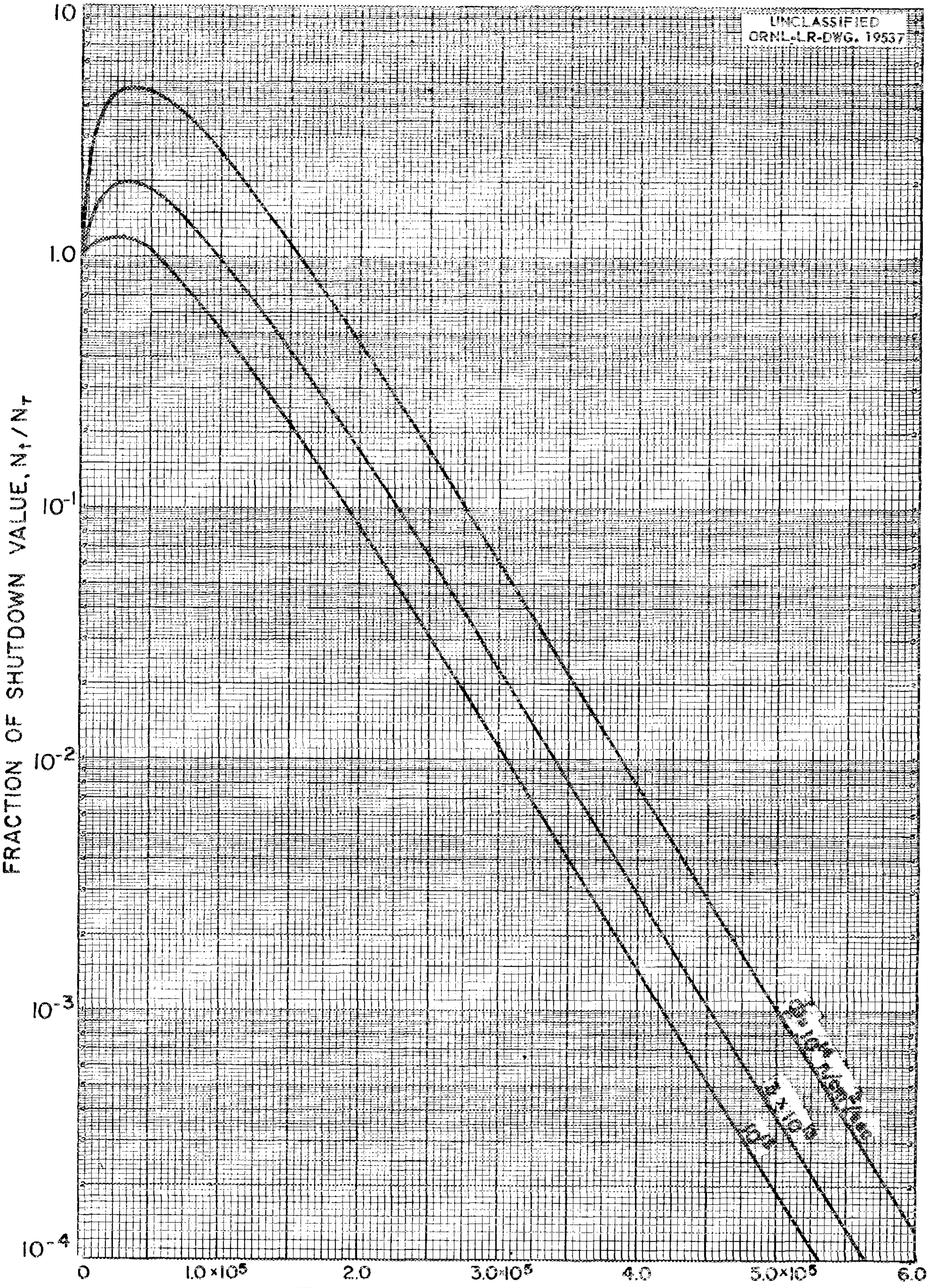

Fig. C-18a. Fraction of Shutdown Value of 9.2h Xe^{135} Remaining at Various Times After Shutdown.

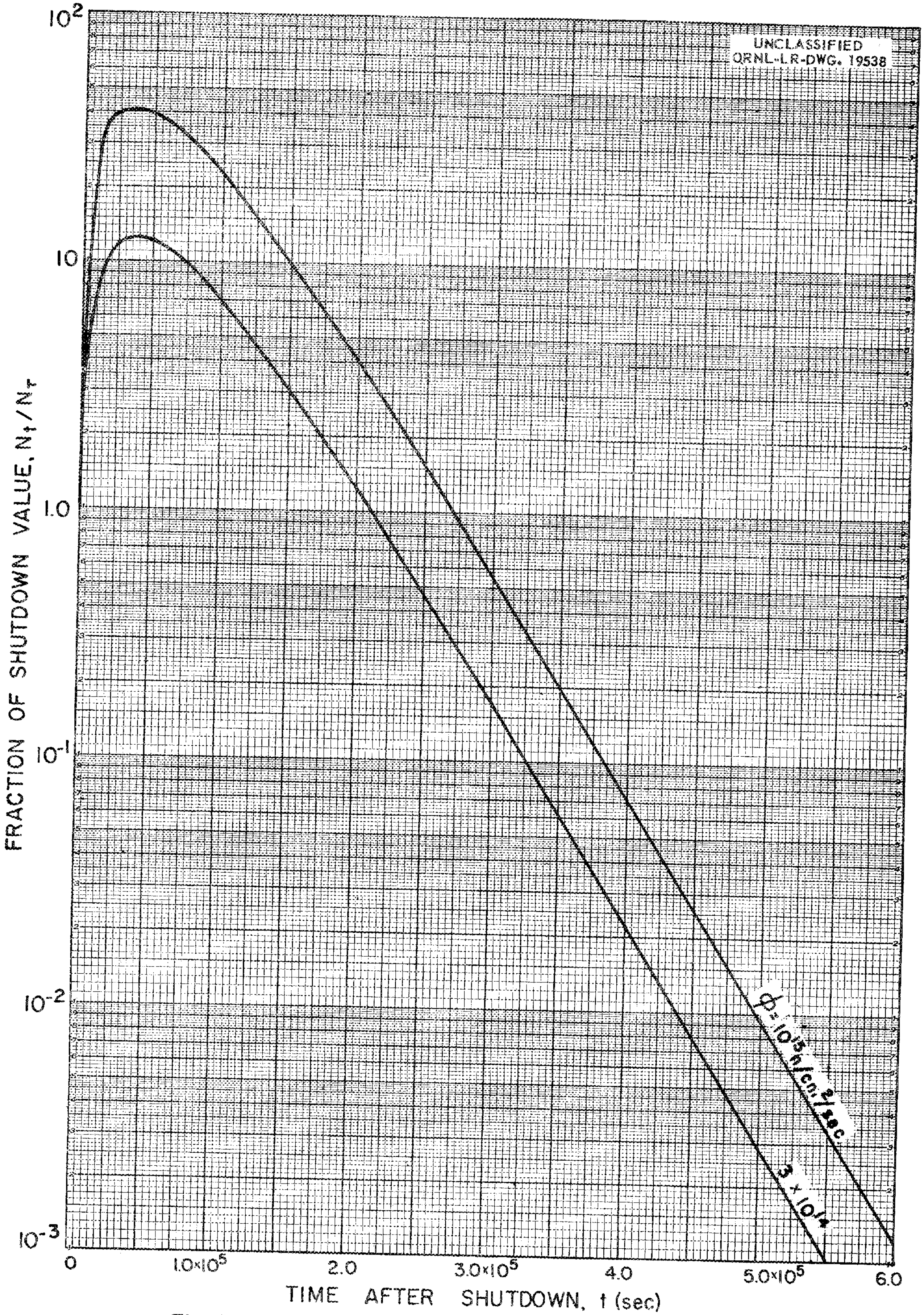

Fig. C-18b. Fraction of Shutdown Value of 9.2h Xe^{135} Remaining at Various Times After Shutdown.

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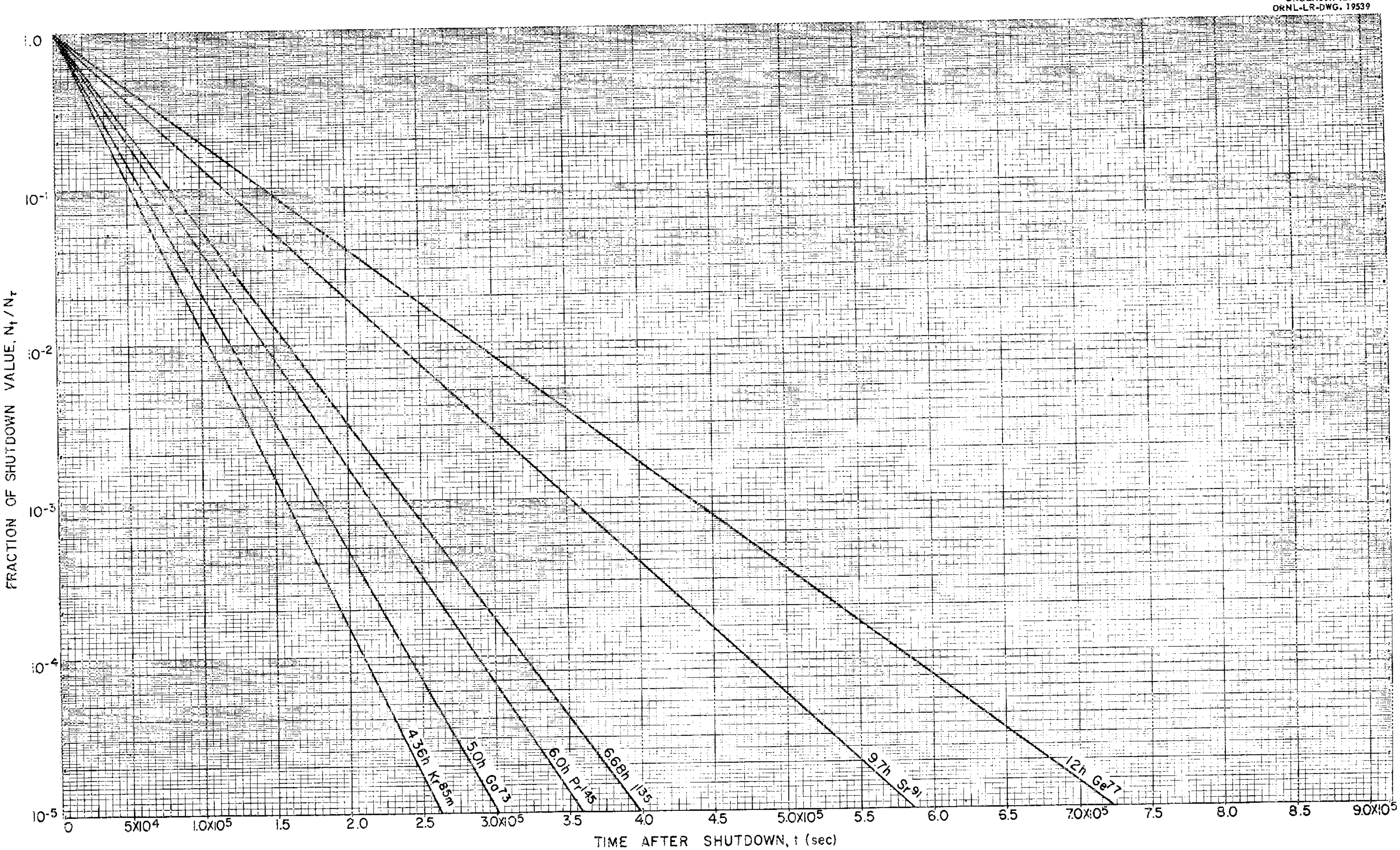

Fig. C-19. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

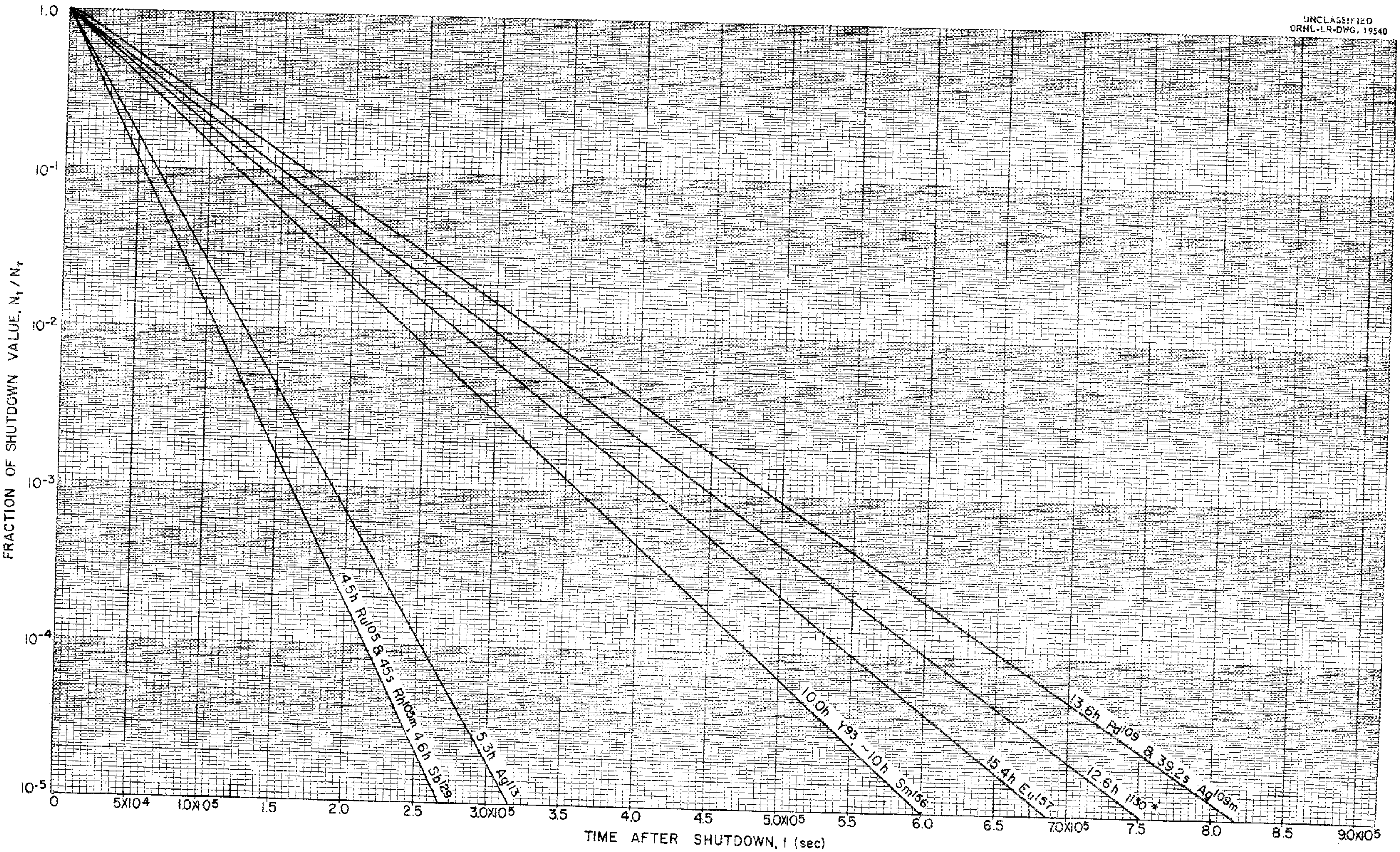

Fig. C-20. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

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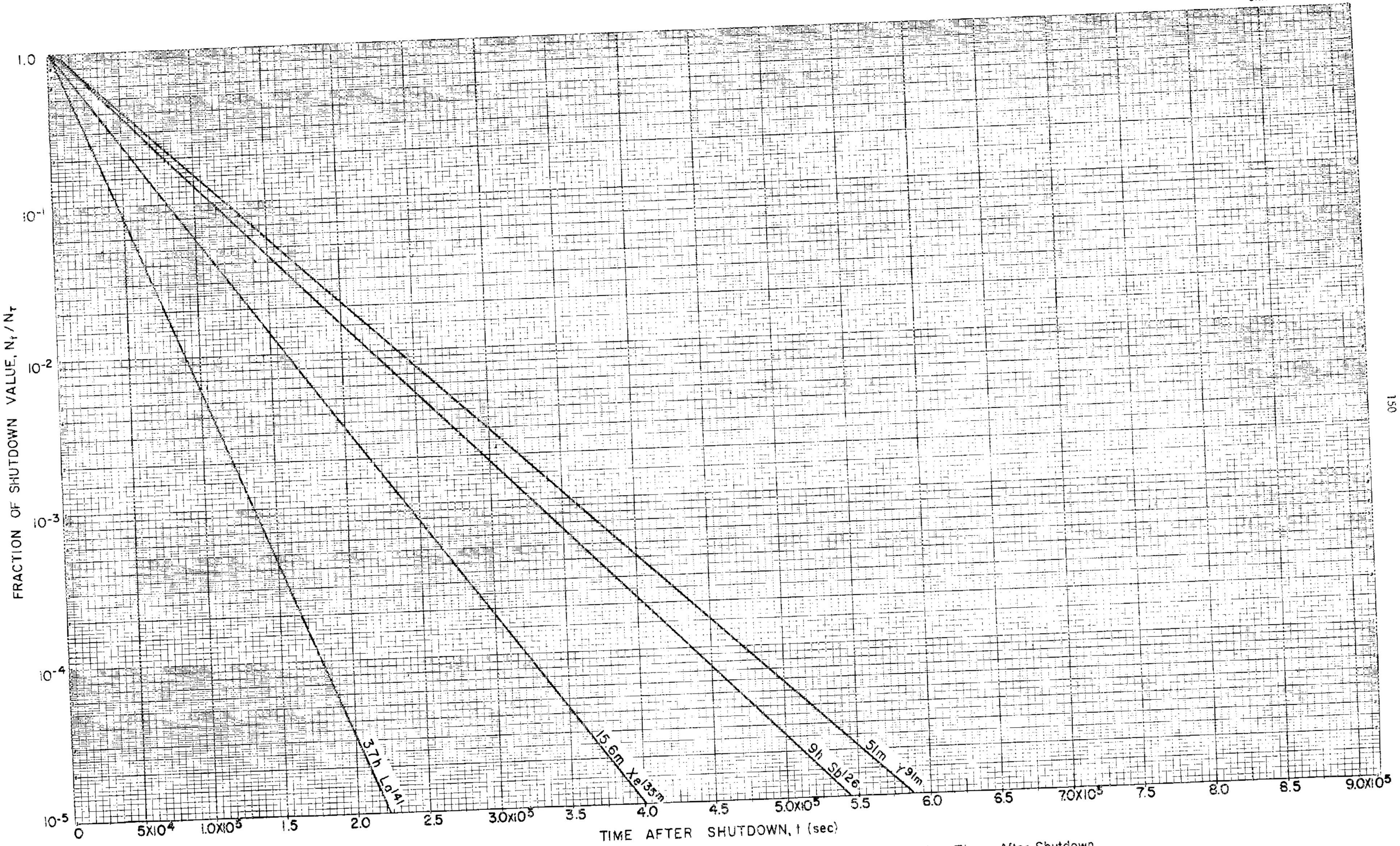

Fig. C-21. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

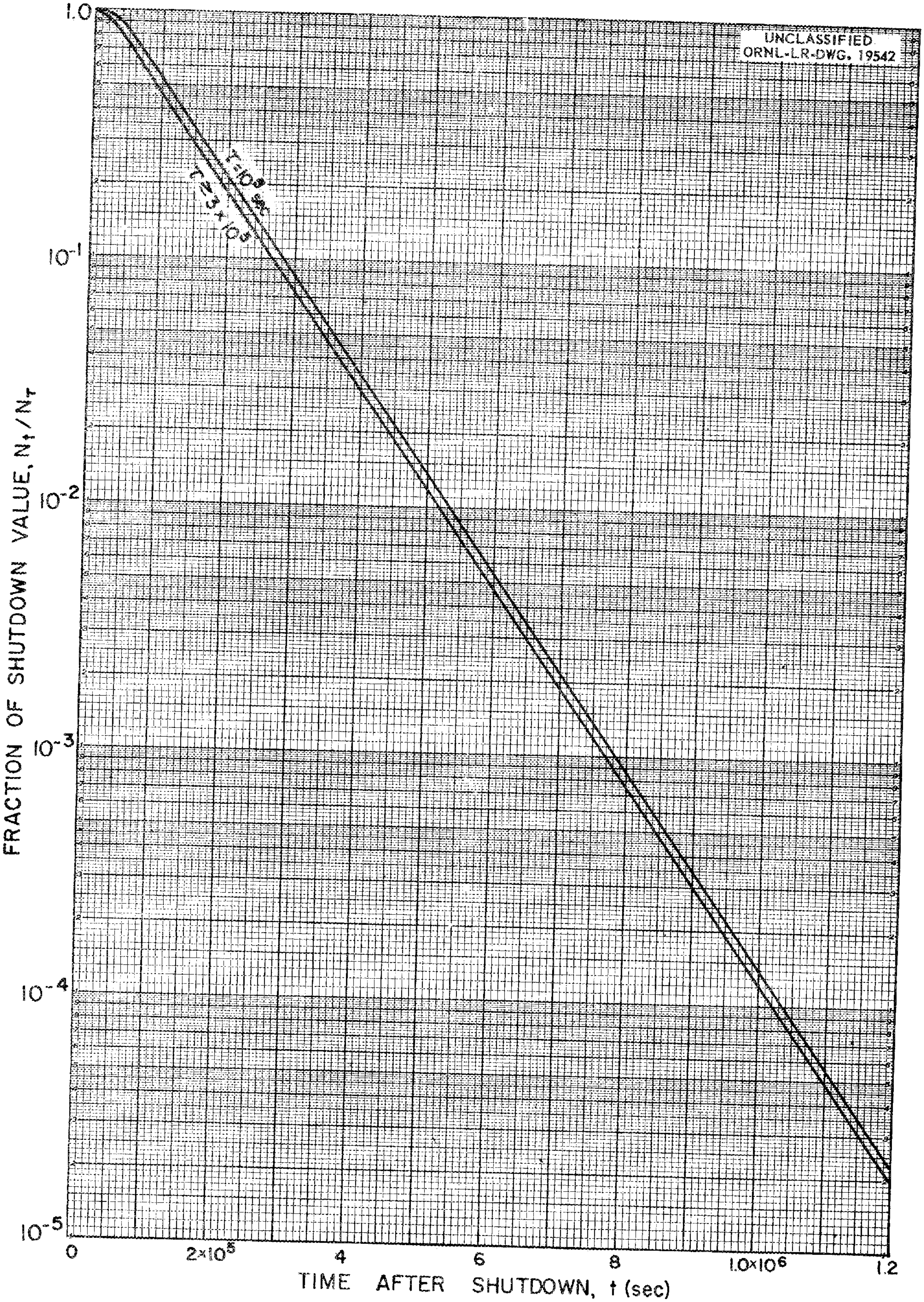

Fig. C-22. Fraction of Shutdown Value of 3.2h Ag^{112} Remaining at Various Times After Shutdown.

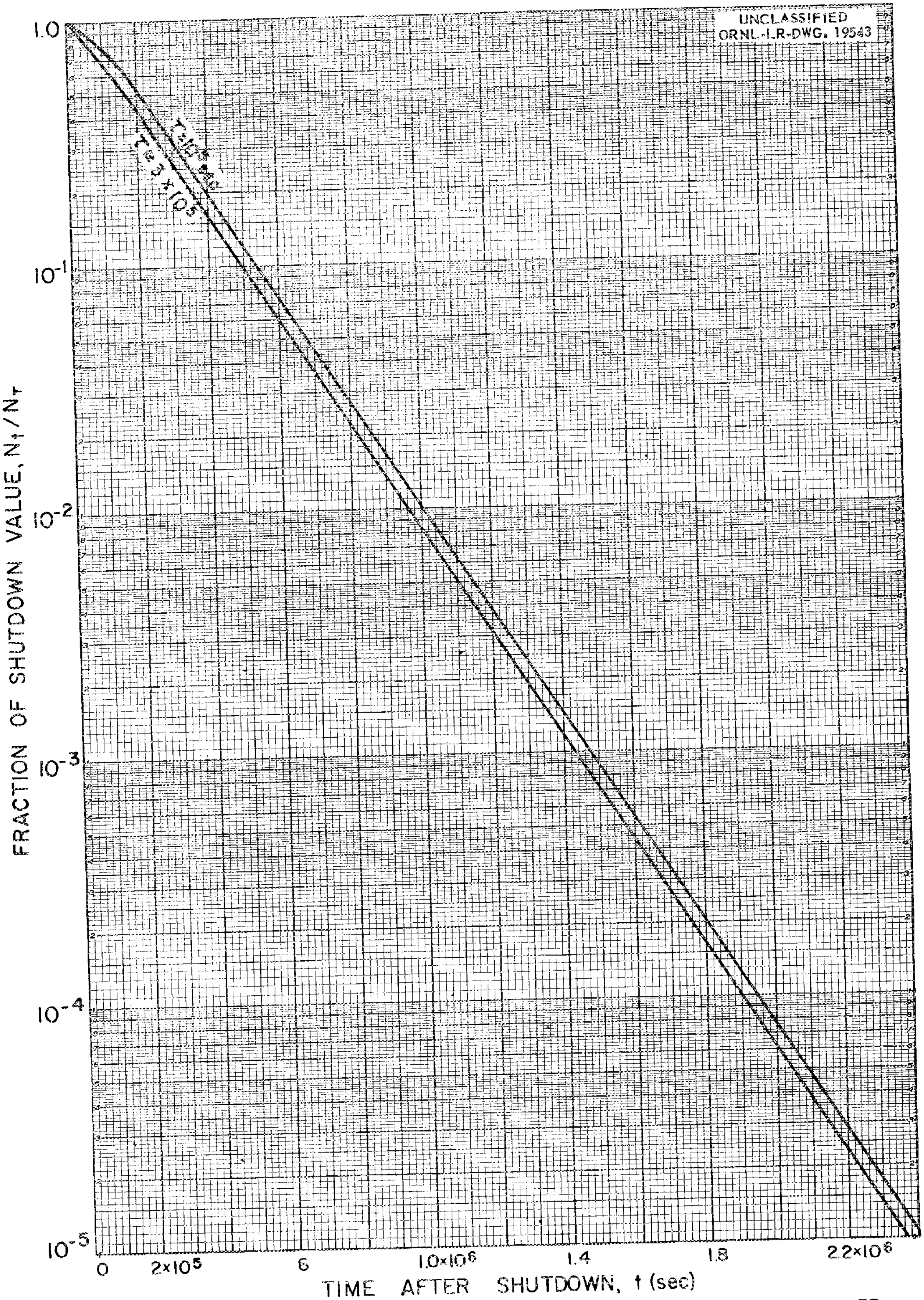

Fig. C-23. Fraction of Shutdown Value of 38.8h As^{77} & 17.5s Se^{77m} Remaining at Various Times After Shutdown.

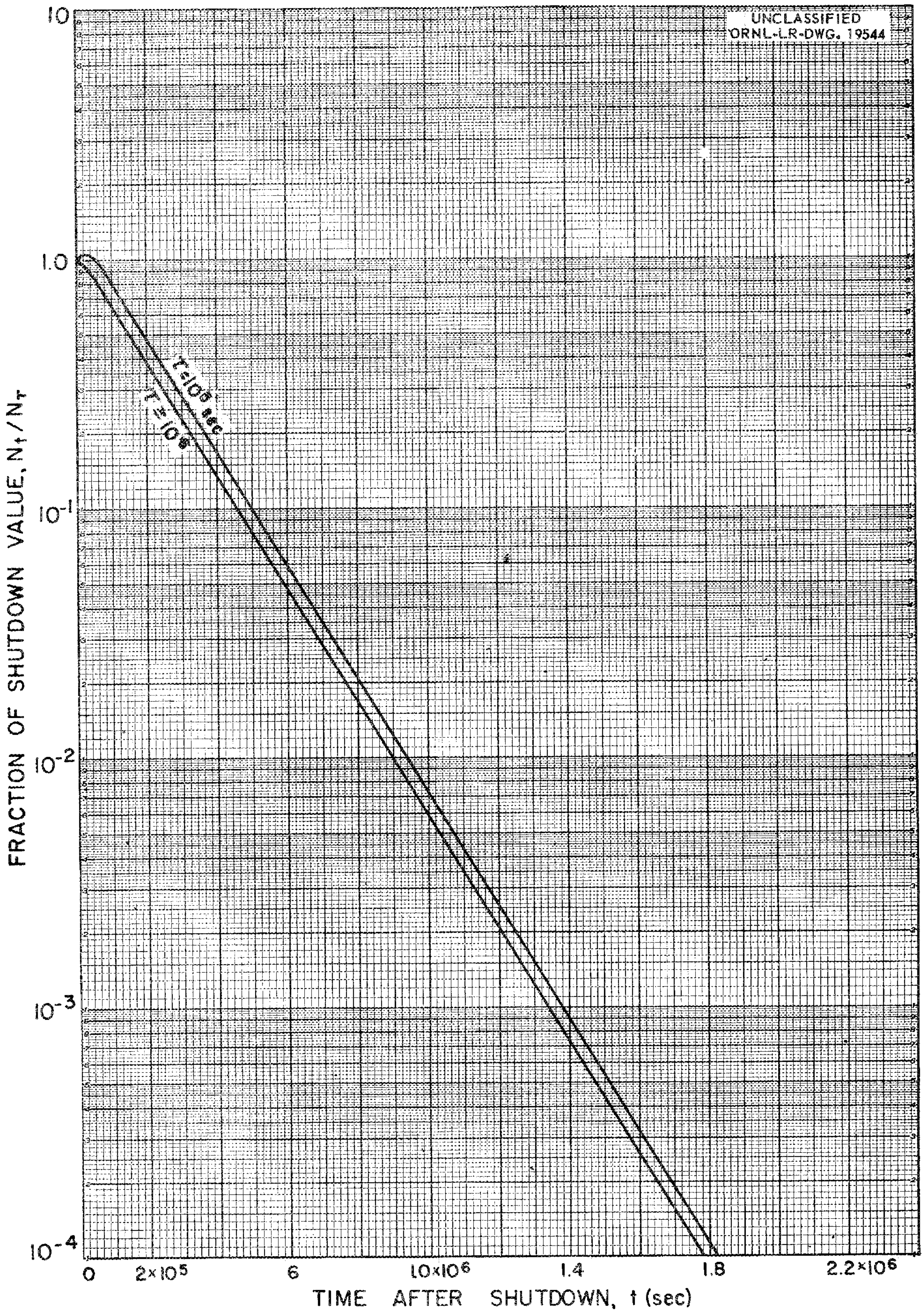

Fig. C-24. Fraction of Shutdown Value of 36.5h Rh^{105} Remaining at Various Times After Shutdown.

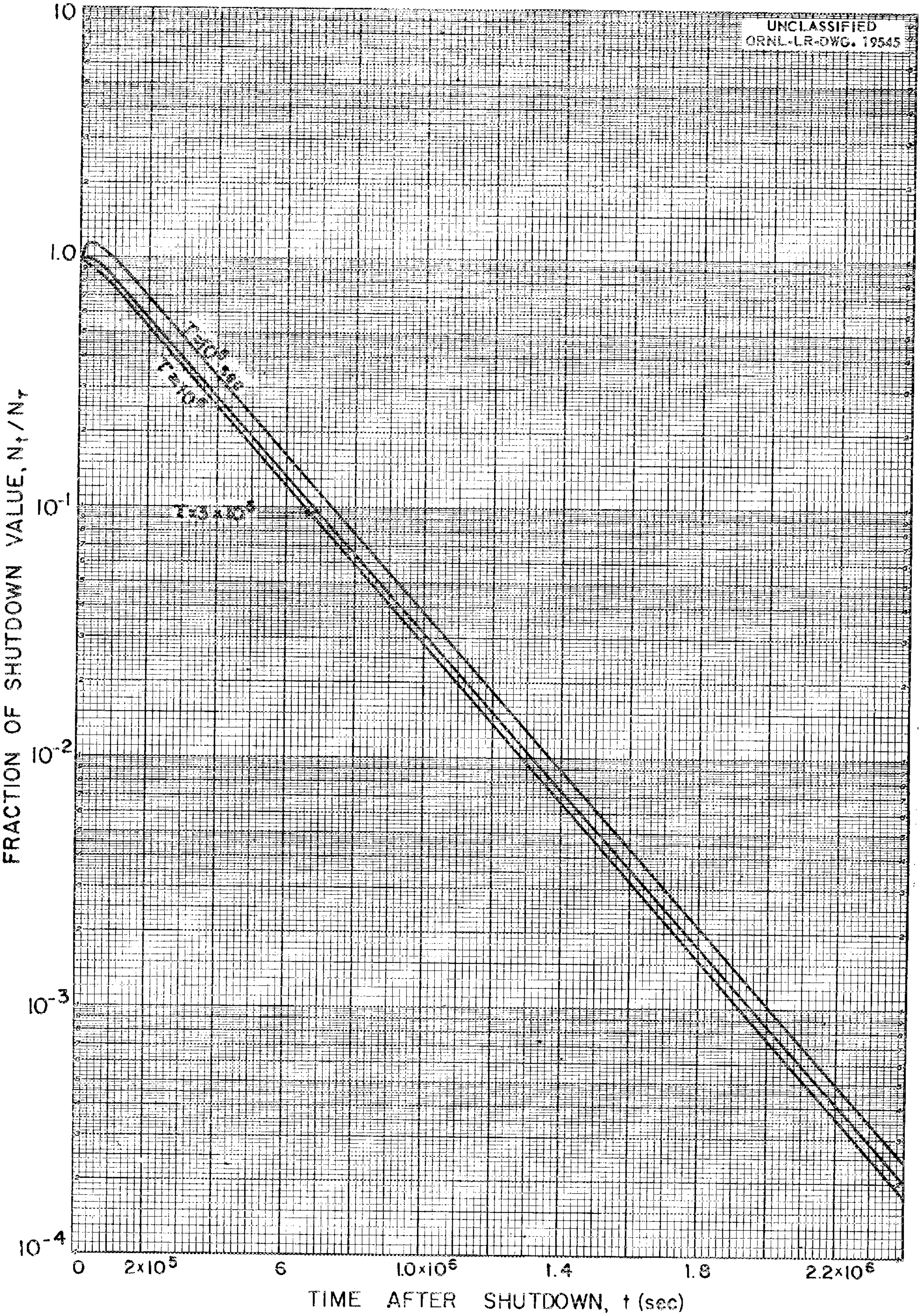

Fig. C-25. Fraction of Shutdown Value of 4.5h In^{115m} Remaining at Various Times After Shutdown.

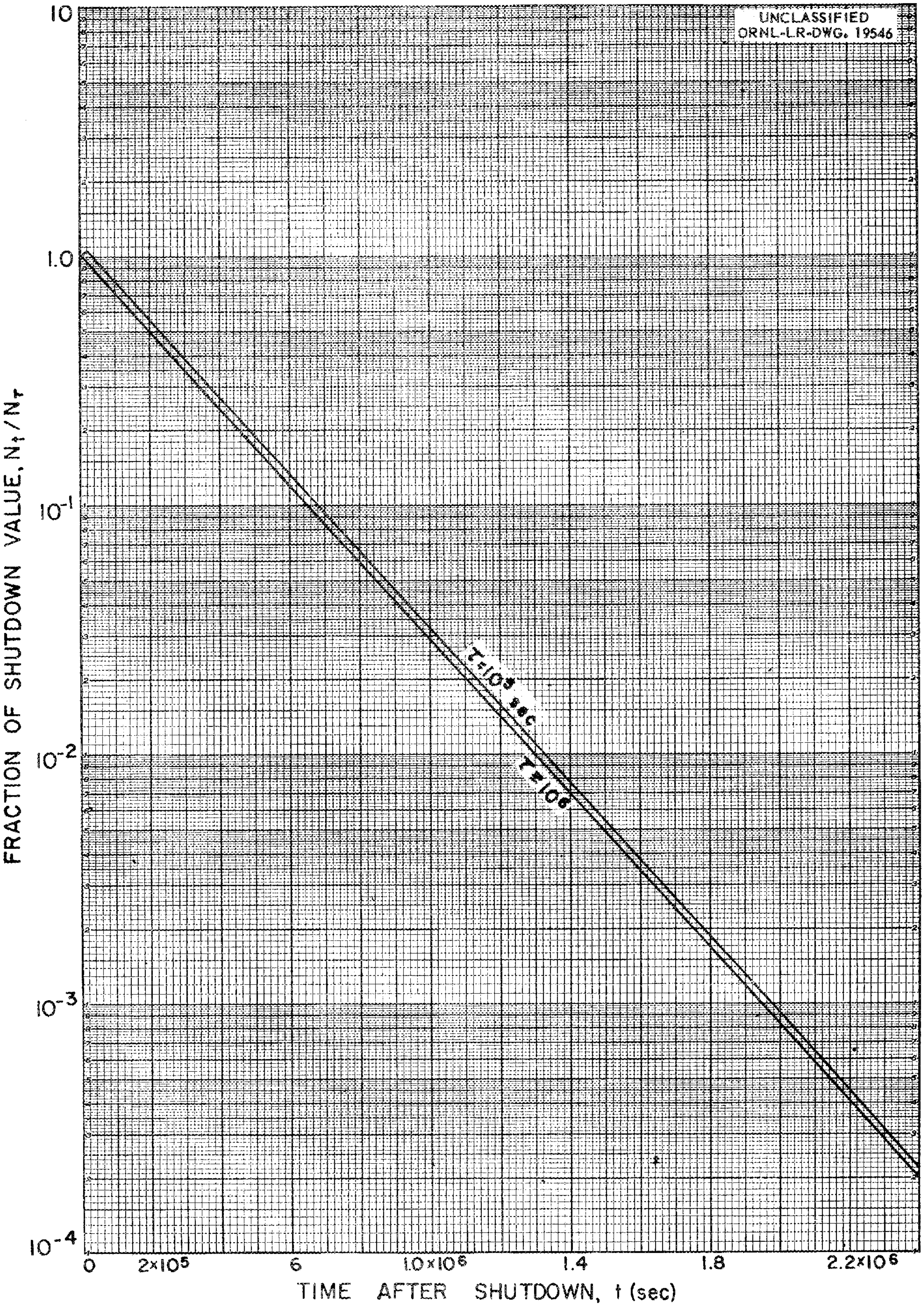

Fig. C-26. Fraction of Shutdown Value of 54h Pm^{149} Remaining at Various Times After Shutdown.

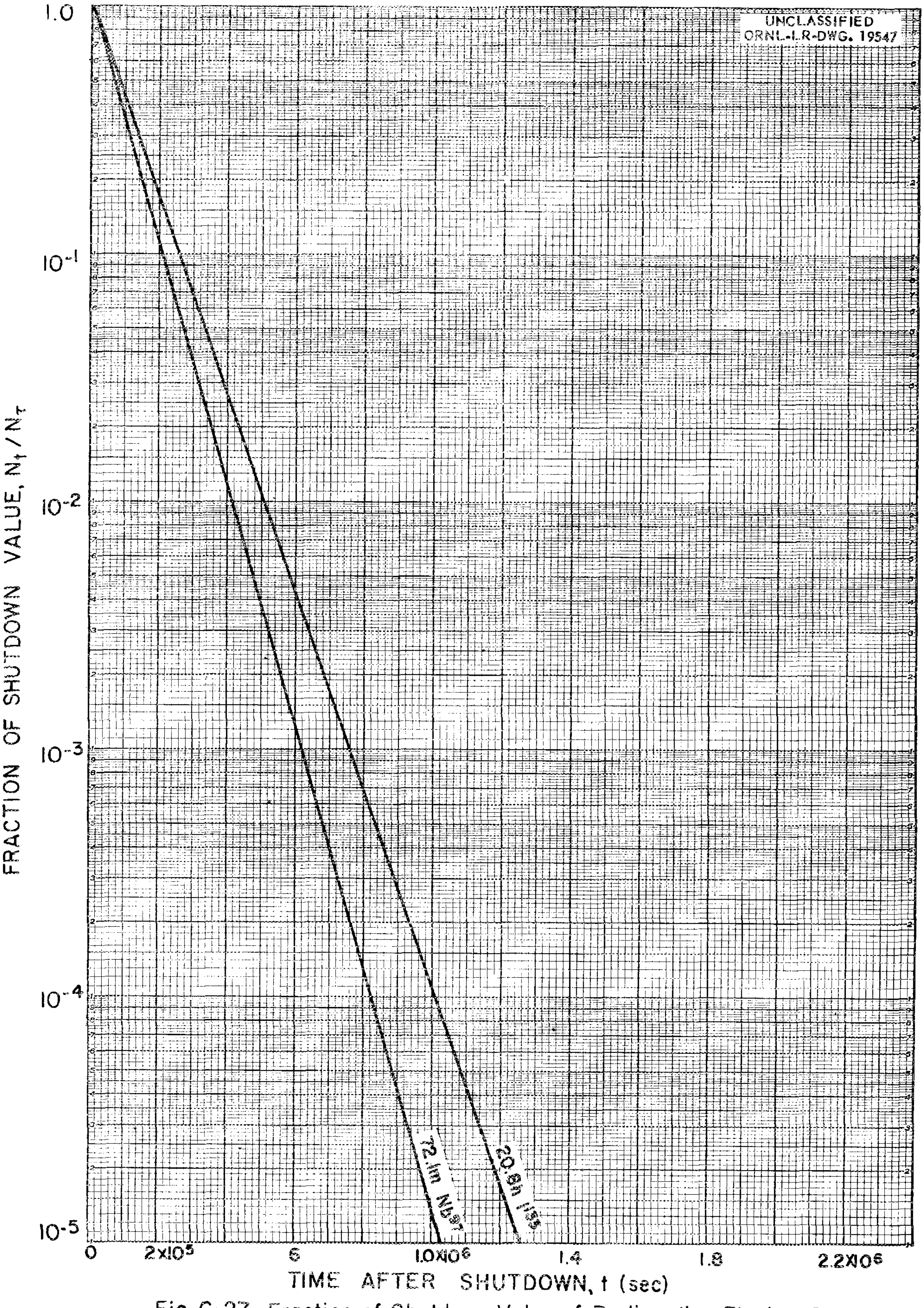

Fig. C-27. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

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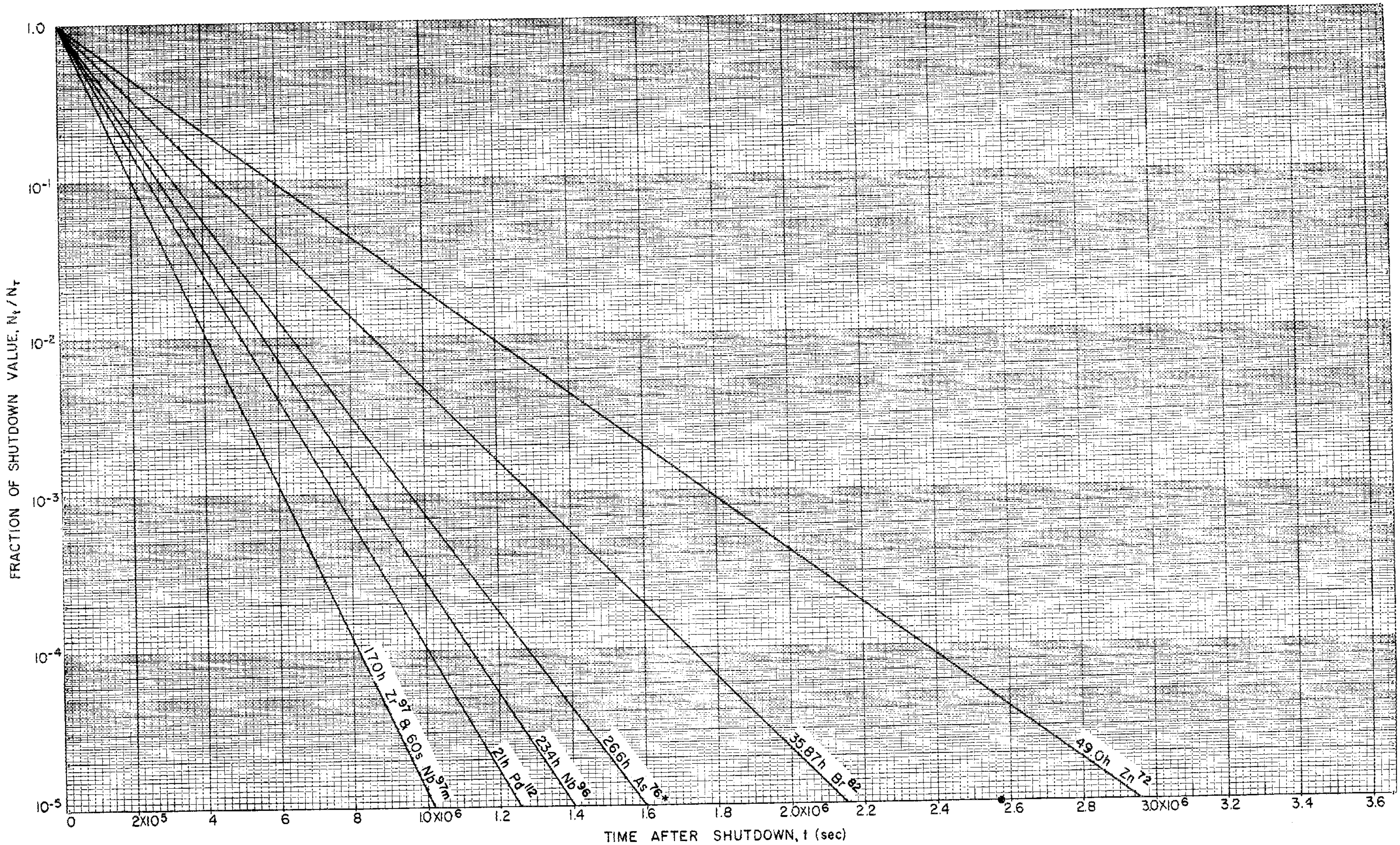

Fig. C-28. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

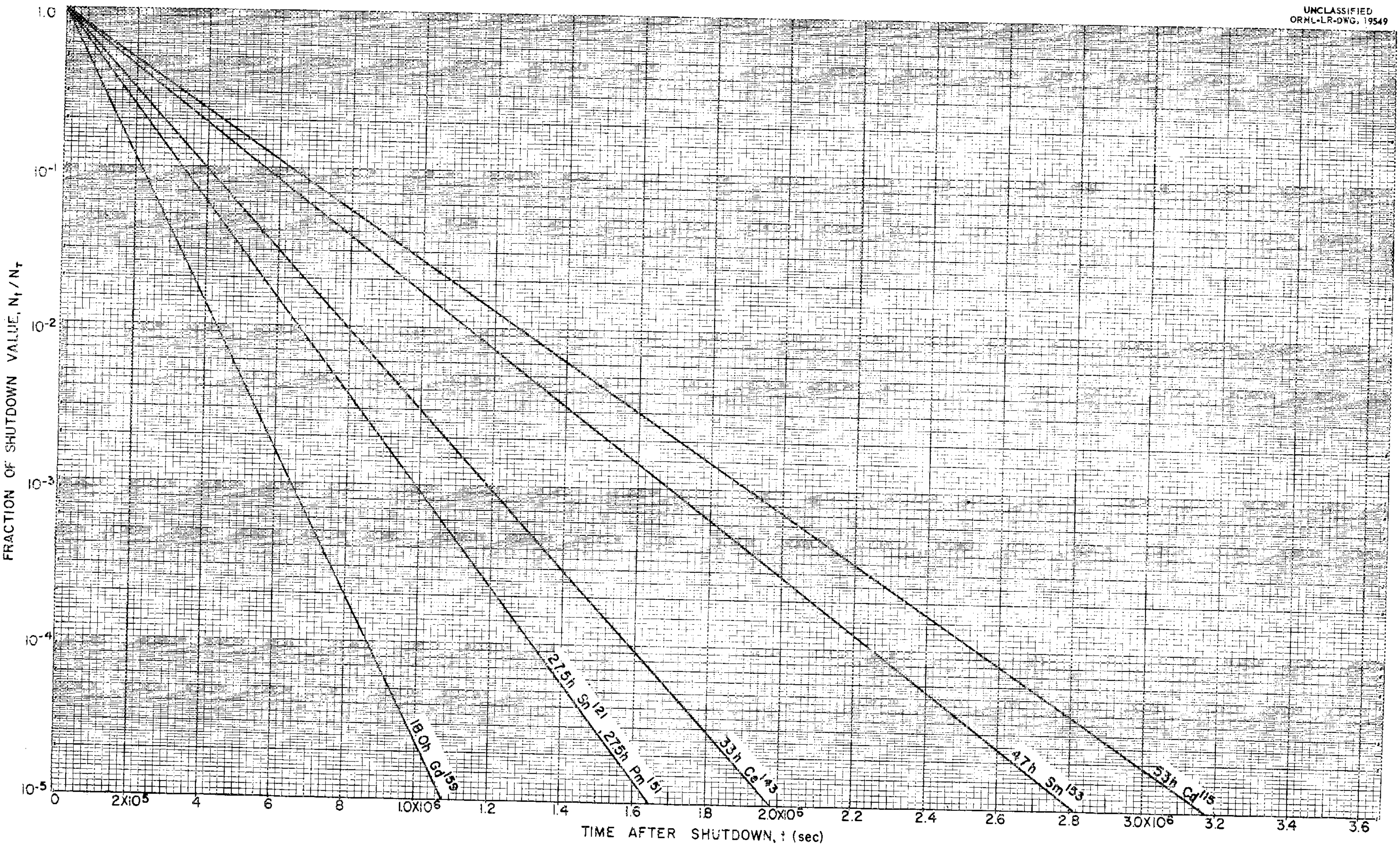

Fig. C-29. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

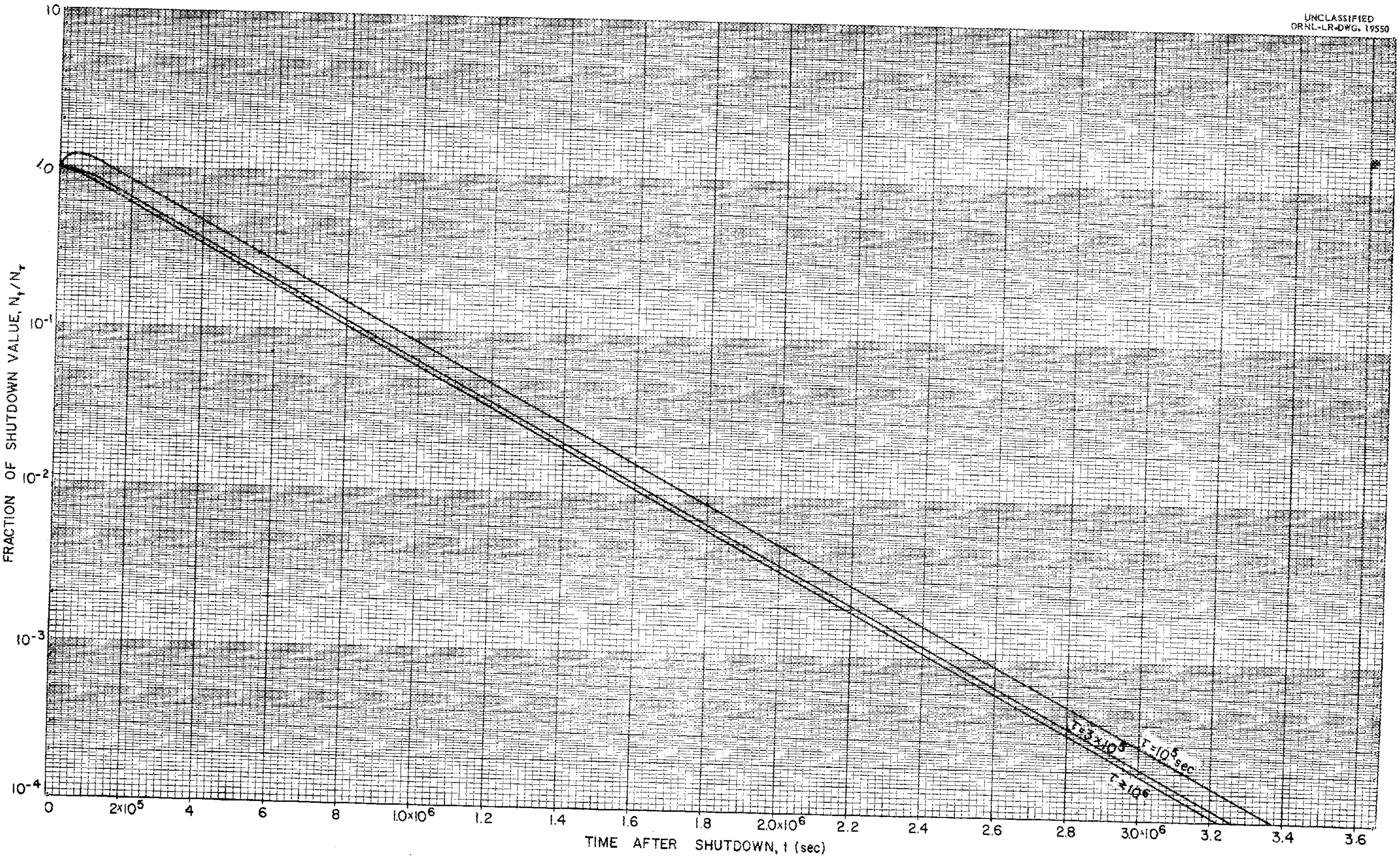

Fig. C-30. Fraction of Shutdown Value of 6.04h Tc^{99m} Remaining at Various Times After Shutdown.

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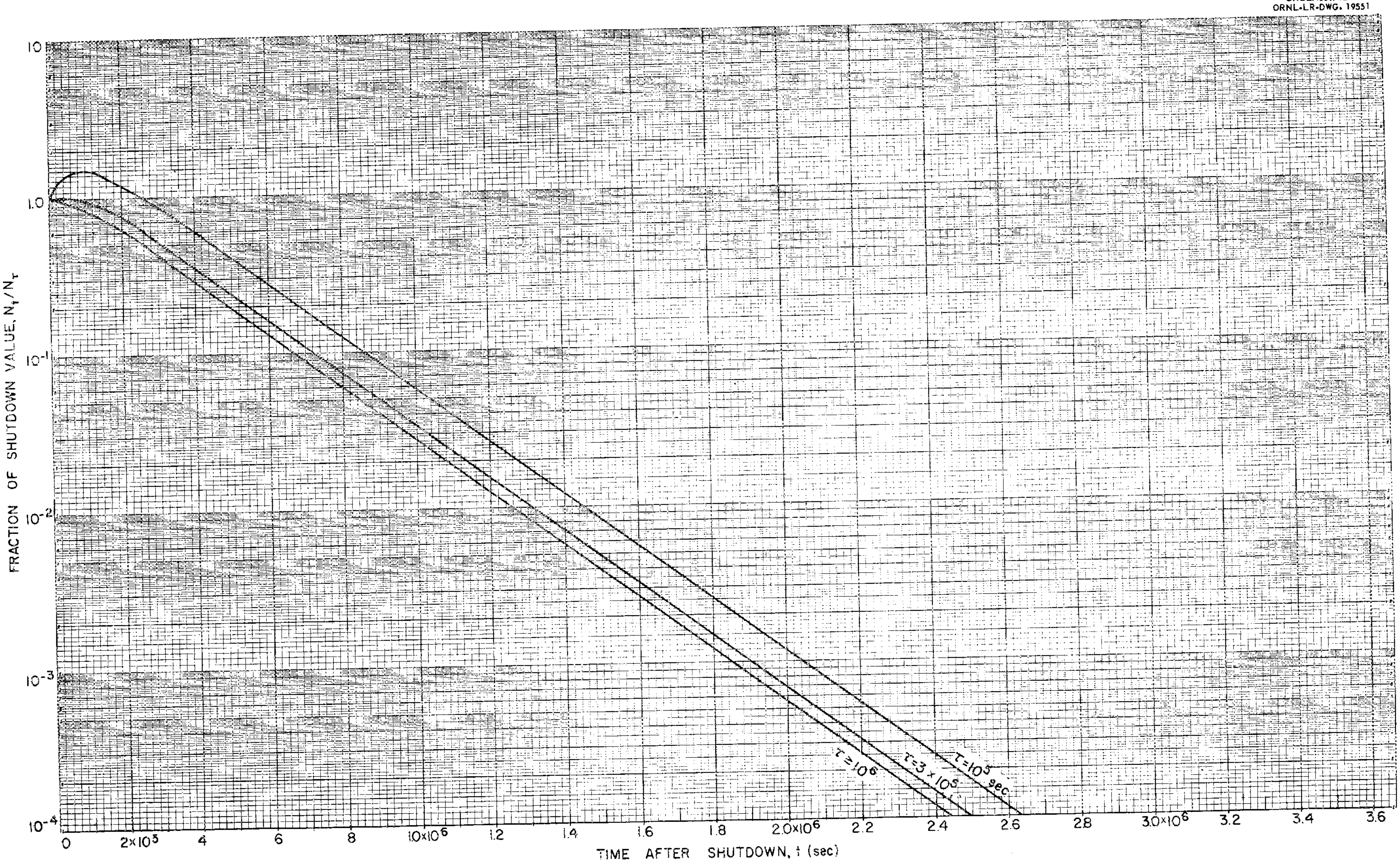

Fig. C-31. Fraction of Shutdown Value of 14.3 h Ga^{72} Remaining at Various Times After Shutdown.

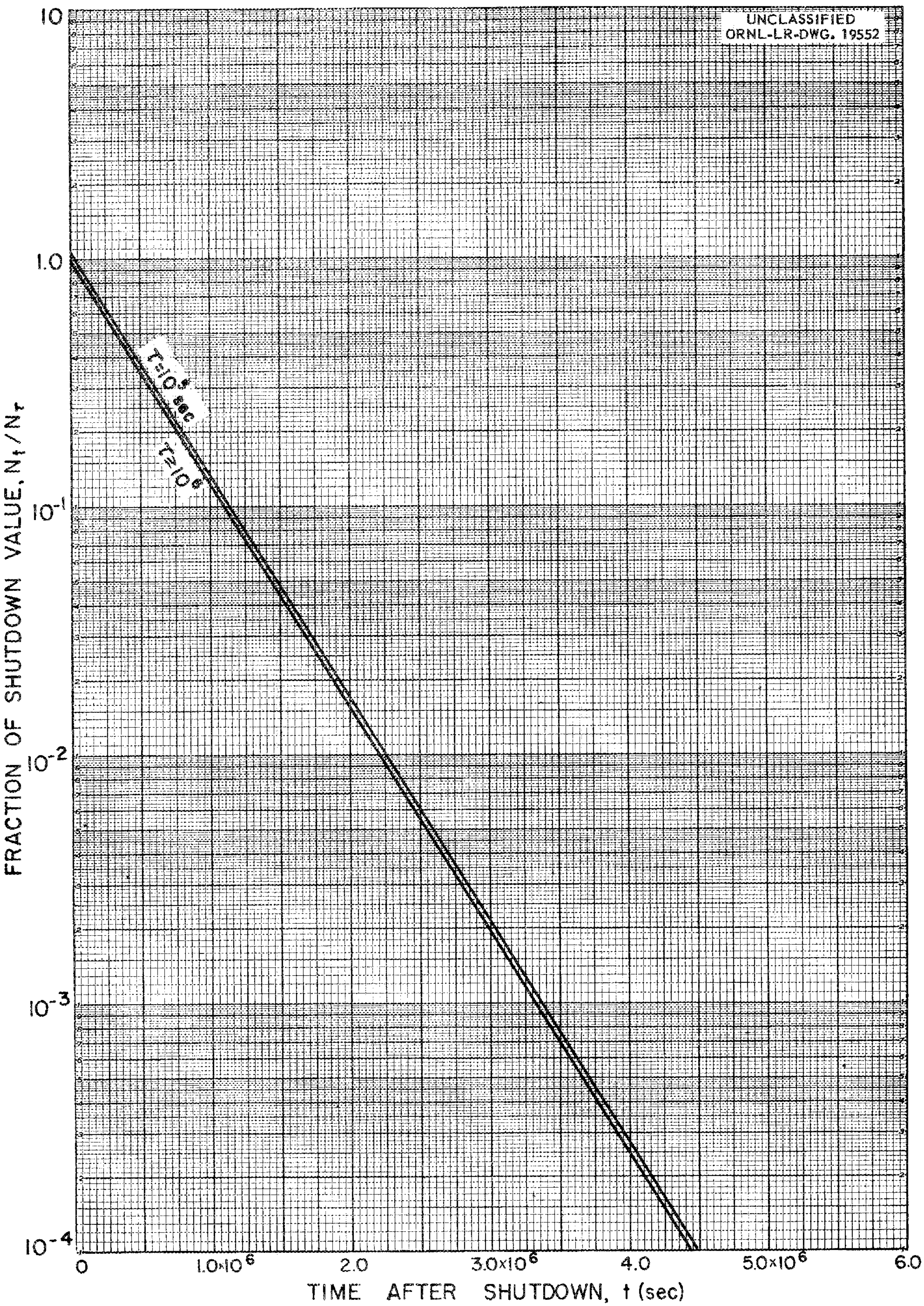

Fig. C-32. Fraction of Shutdown Value of 93h Sb^{127} Remaining at Various Times After Shutdown.

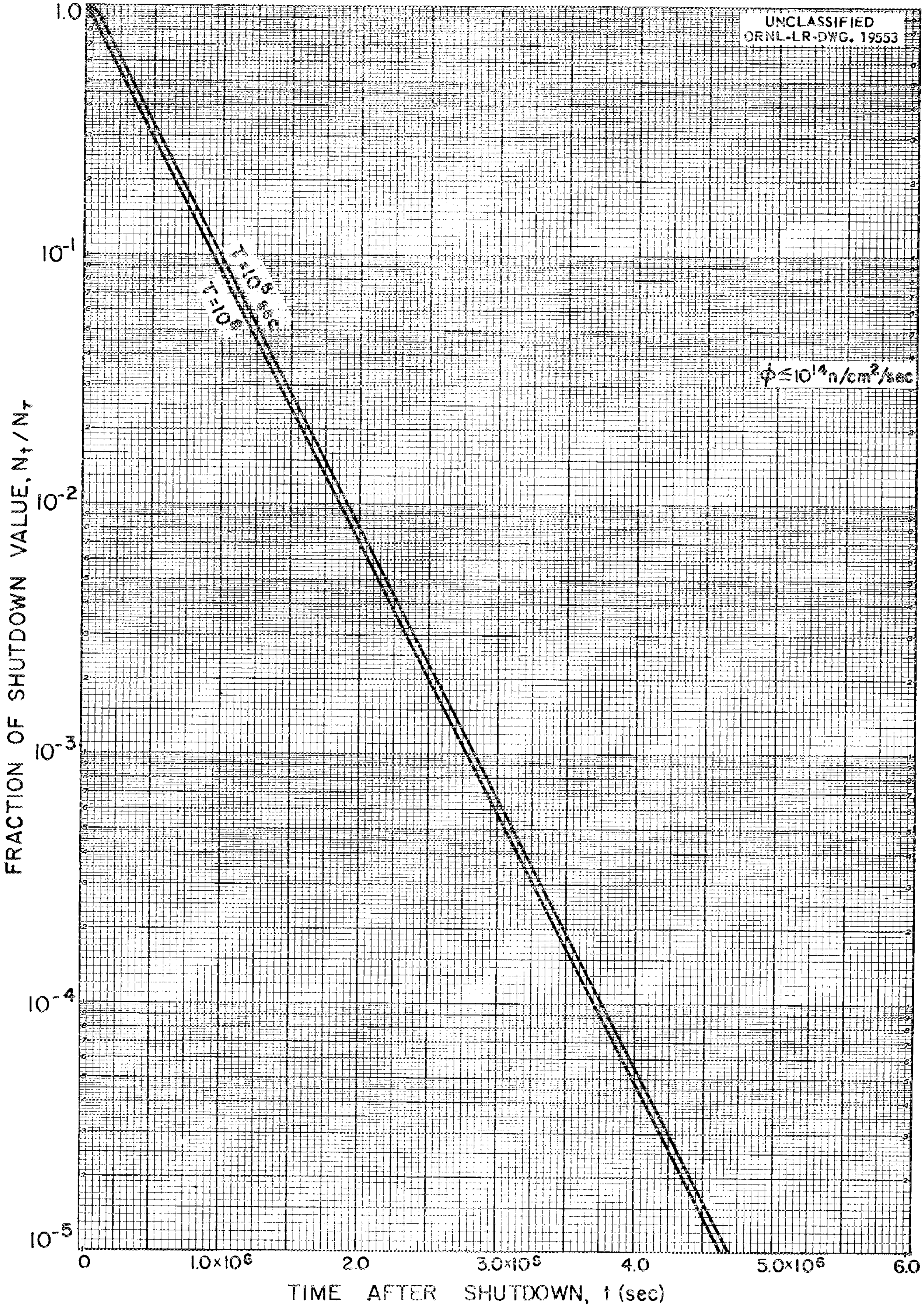

Fig. C-33. Fraction of Shutdown Value of 2.4h I^{132} Remaining at Various Times After Shutdown.

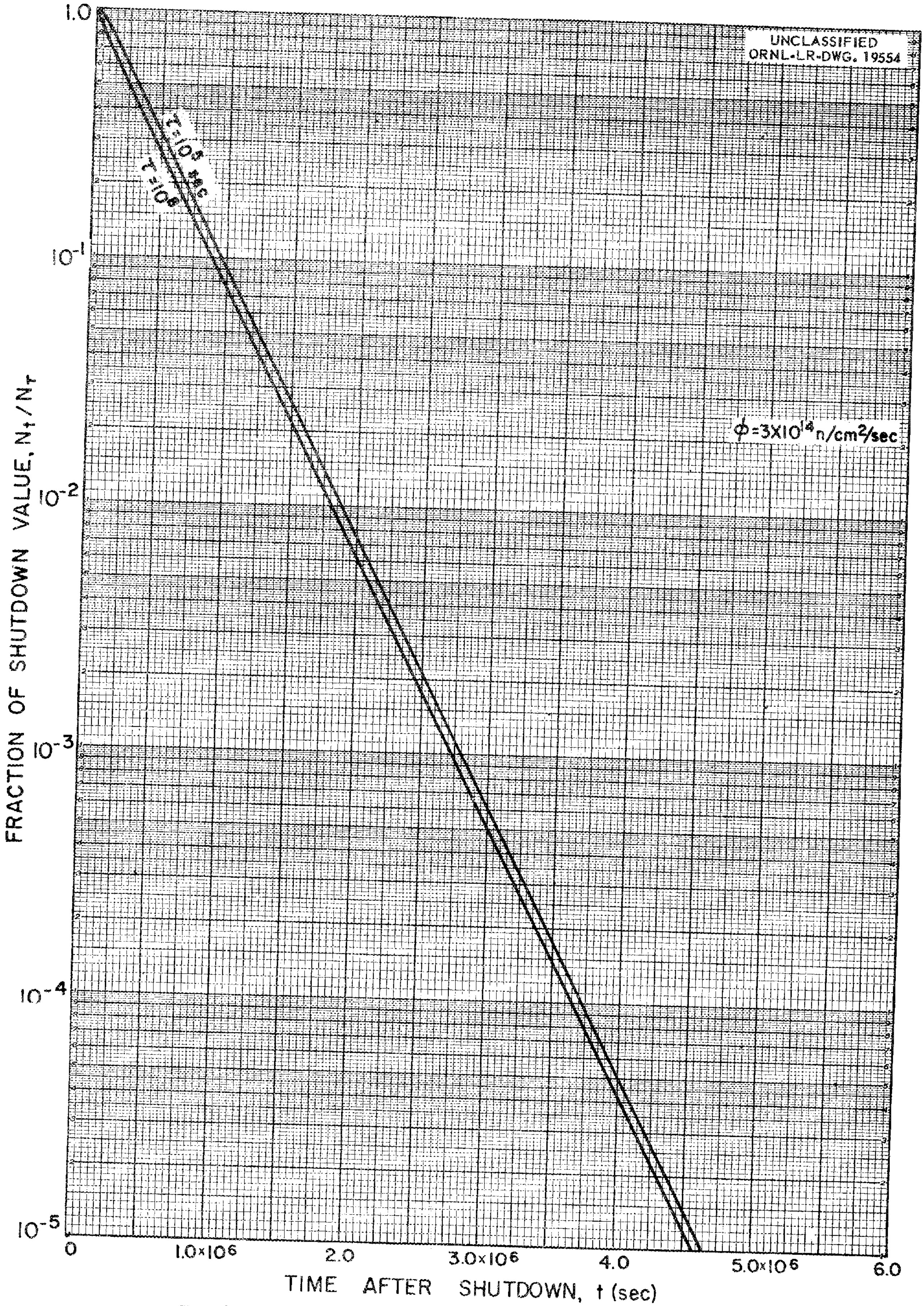

Fig. C-33a. Fraction of Shutdown Value of 2.4h I^{132} Remaining at Various Times After Shutdown.

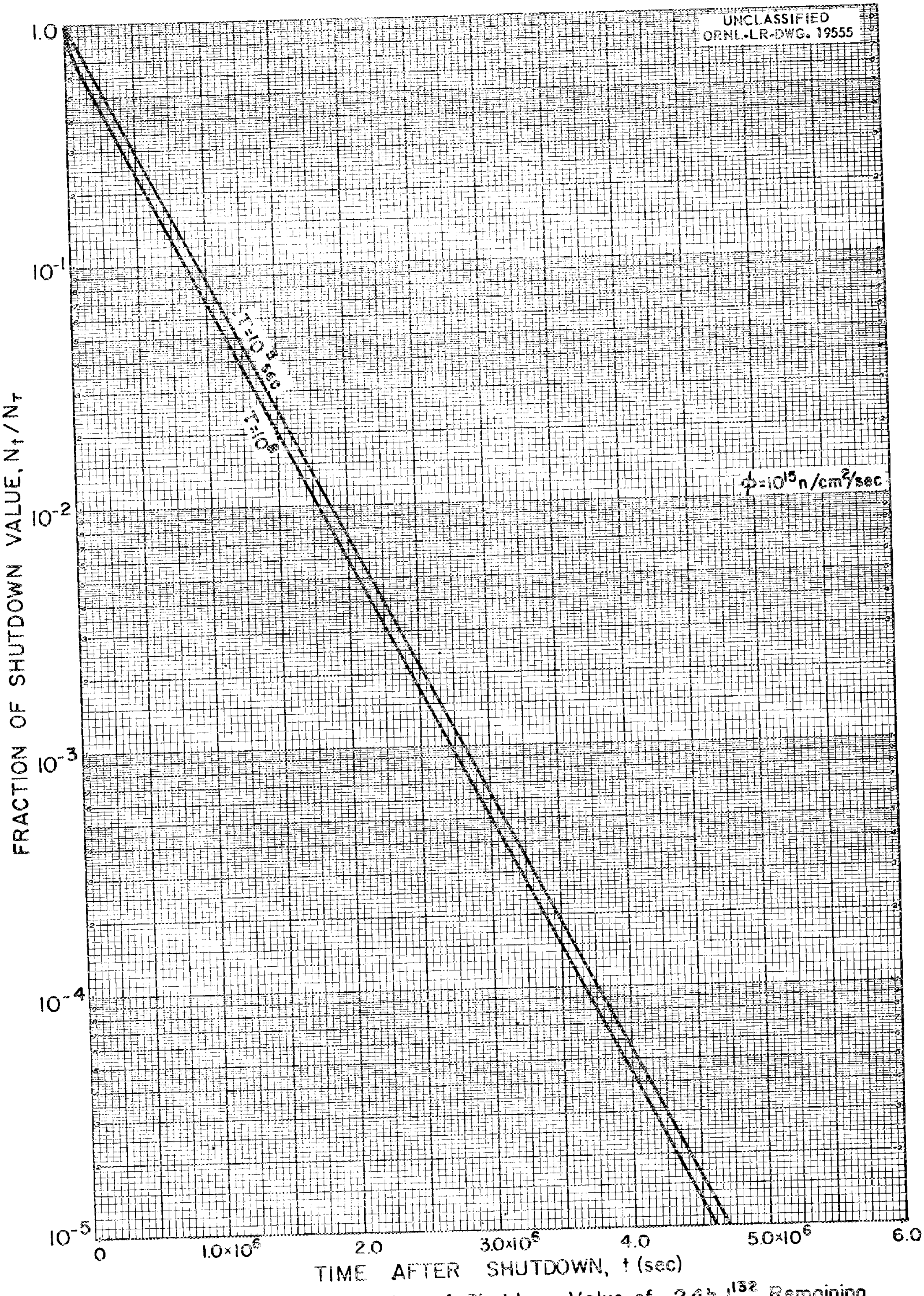

Fig. C-33b. Fraction of Shutdown Value of 2.4h I^{132} Remaining at Various Times After Shutdown.

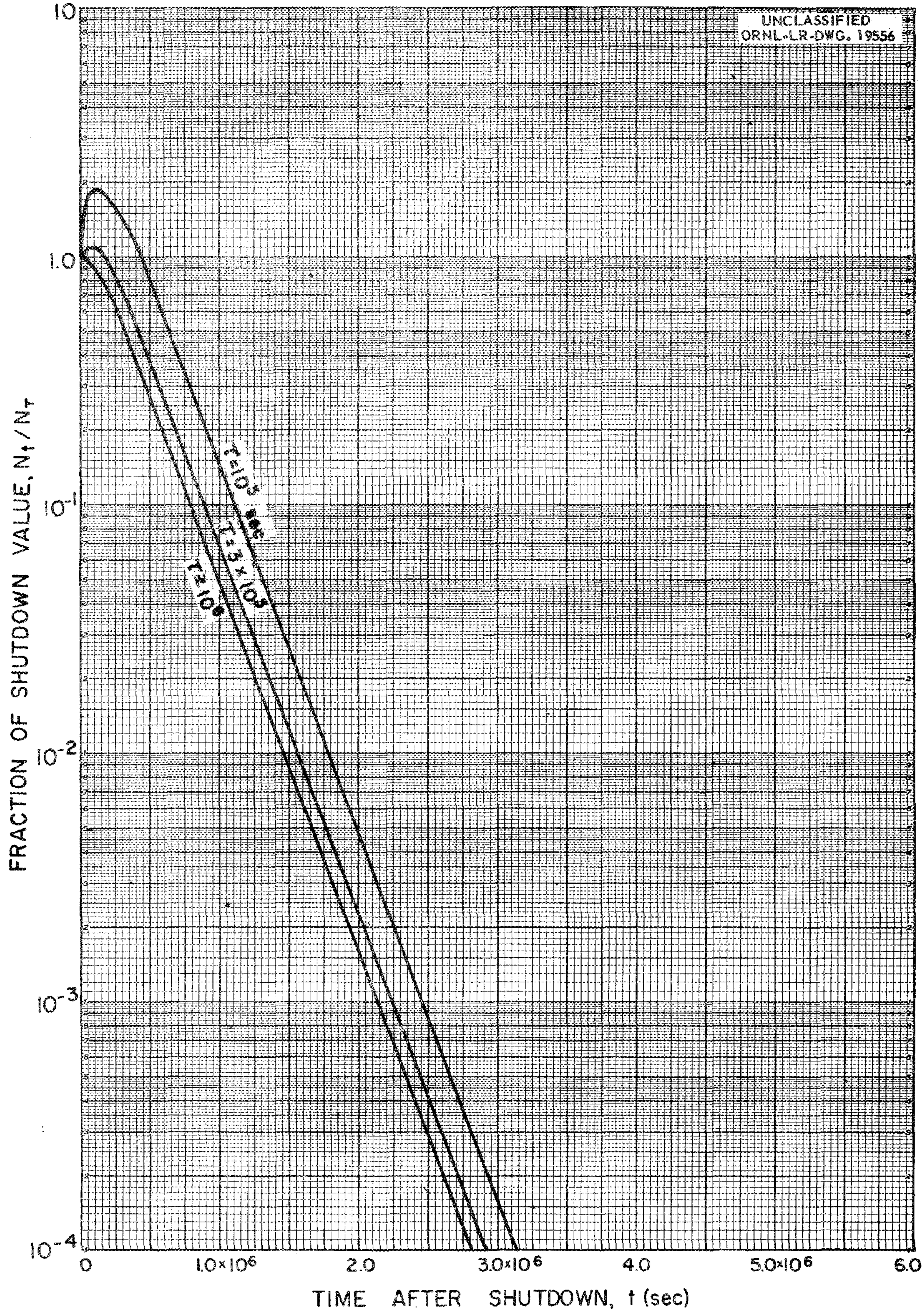

Fig. C-34. Fraction of Shutdown Value of 2.3d Xe^{133m} Remaining at Various Times After Shutdown.

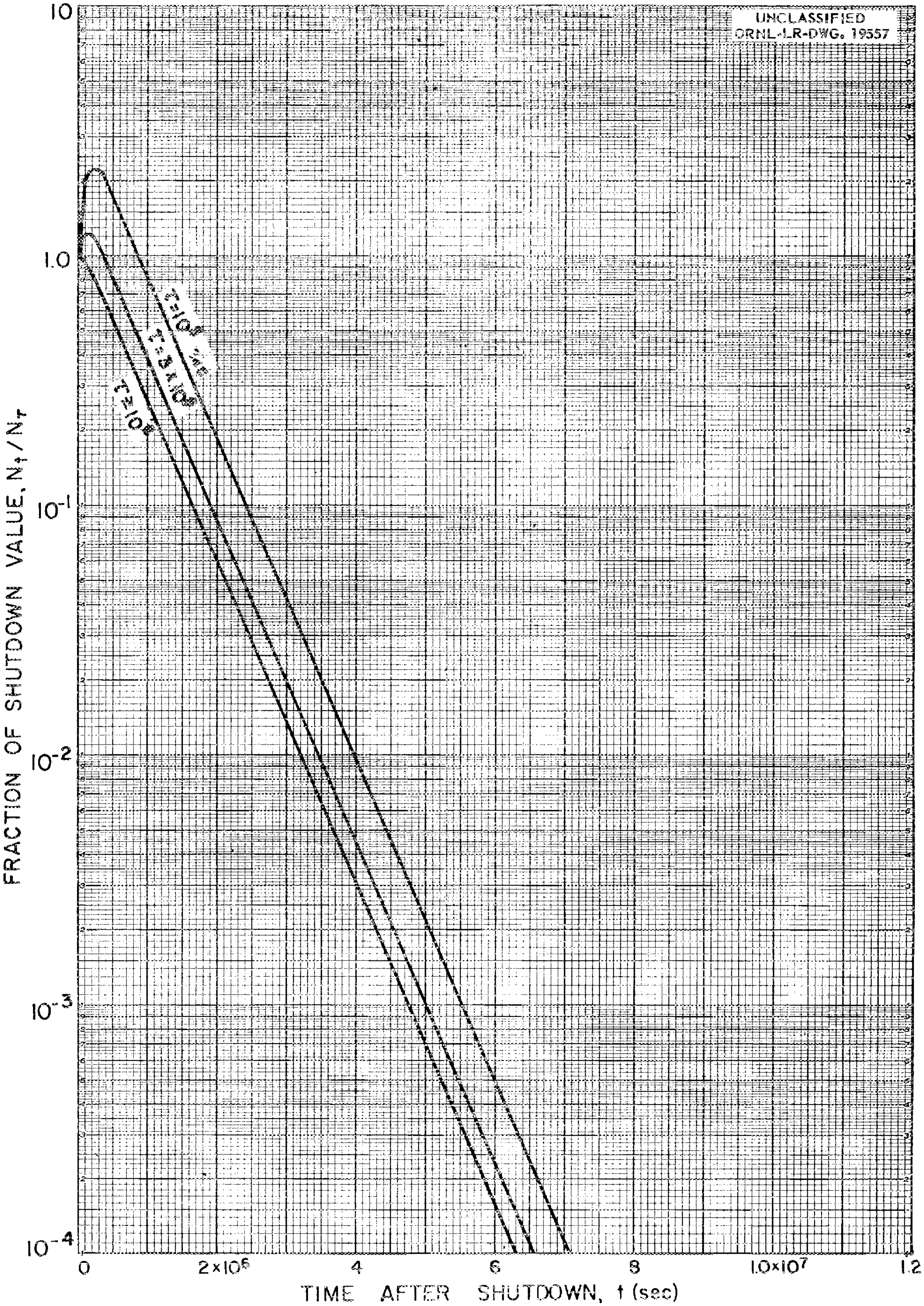

Fig. C-35. Fraction of Shutdown Value of 5.27d Xe^{133} Remaining at Various Times After Shutdown.

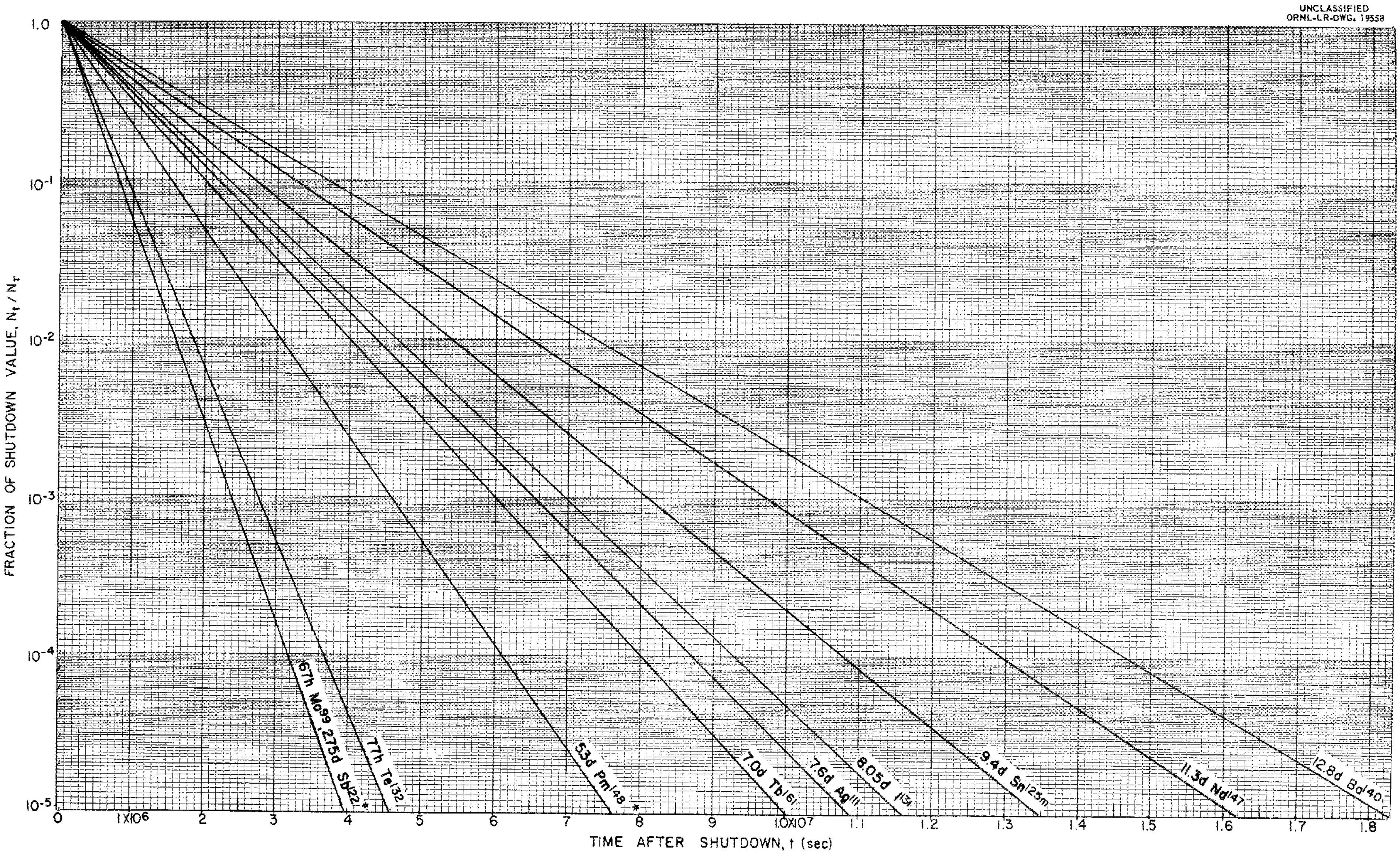

Fig. C-36. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

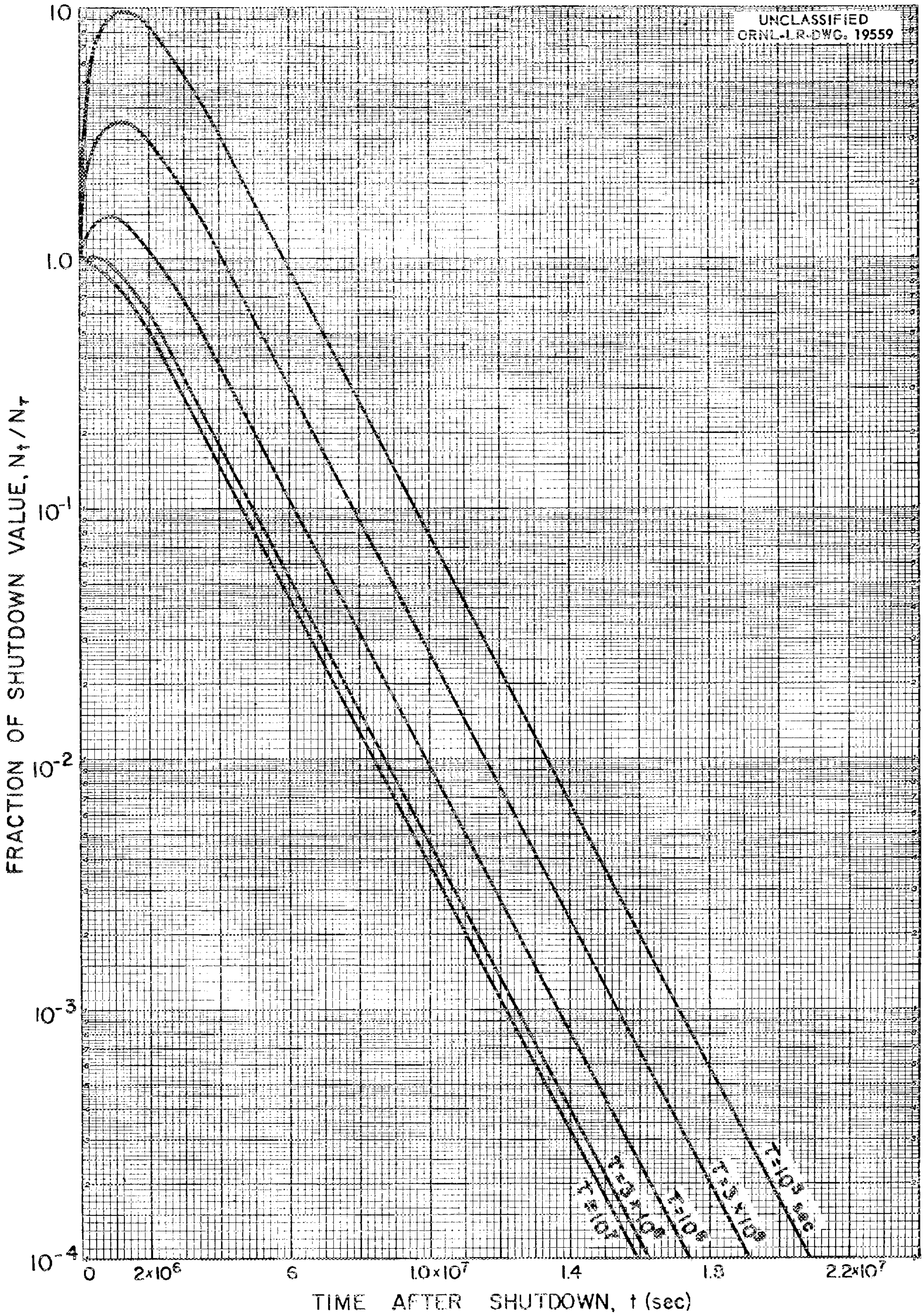

Fig. C-37. Fraction of Shutdown Value of 12d Xe^{131m} Remaining at Various Times After Shutdown.

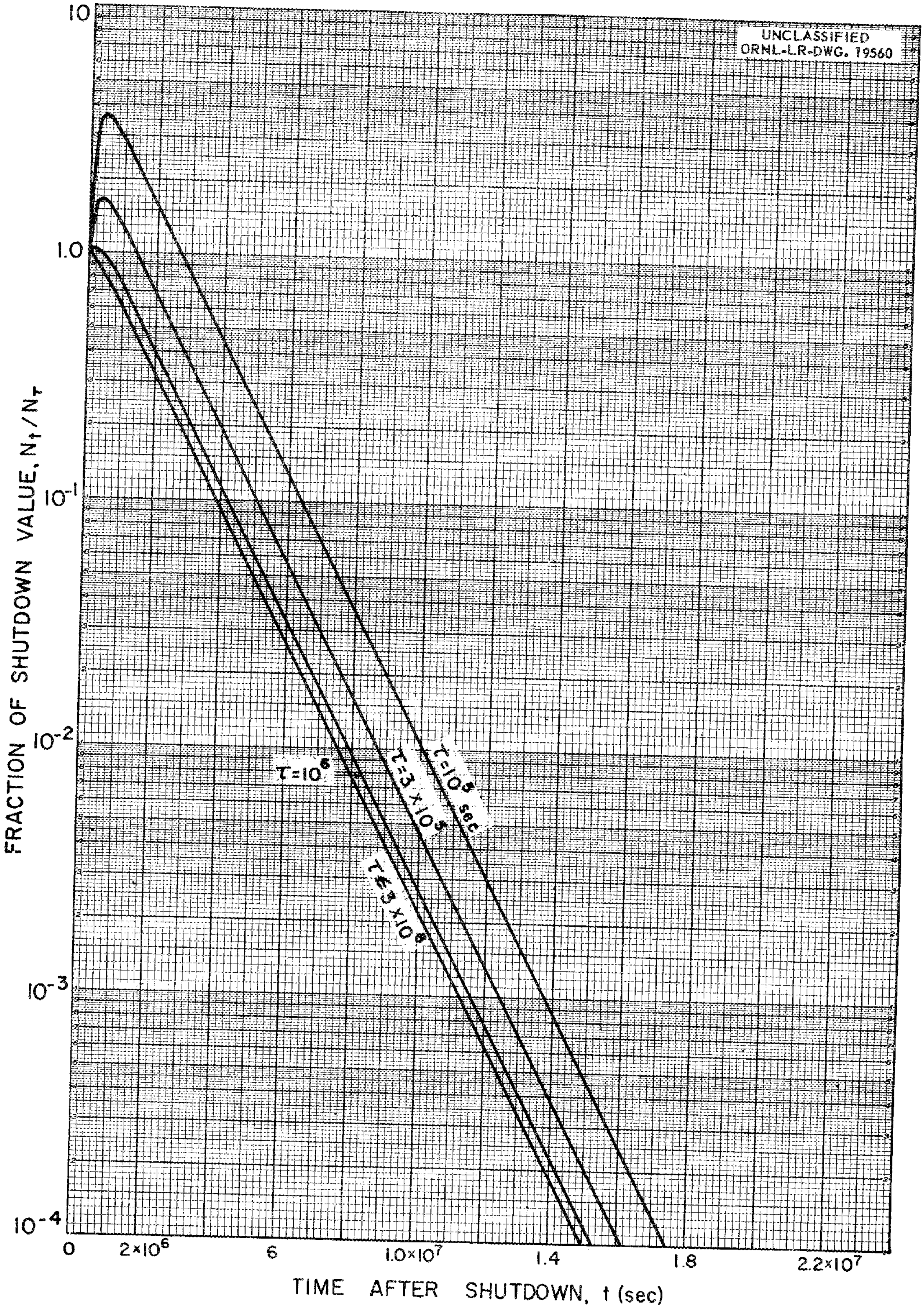

Fig. C-38. Fraction of Shutdown Value of 40.2h La^{140} Remaining at Various Times After Shutdown.

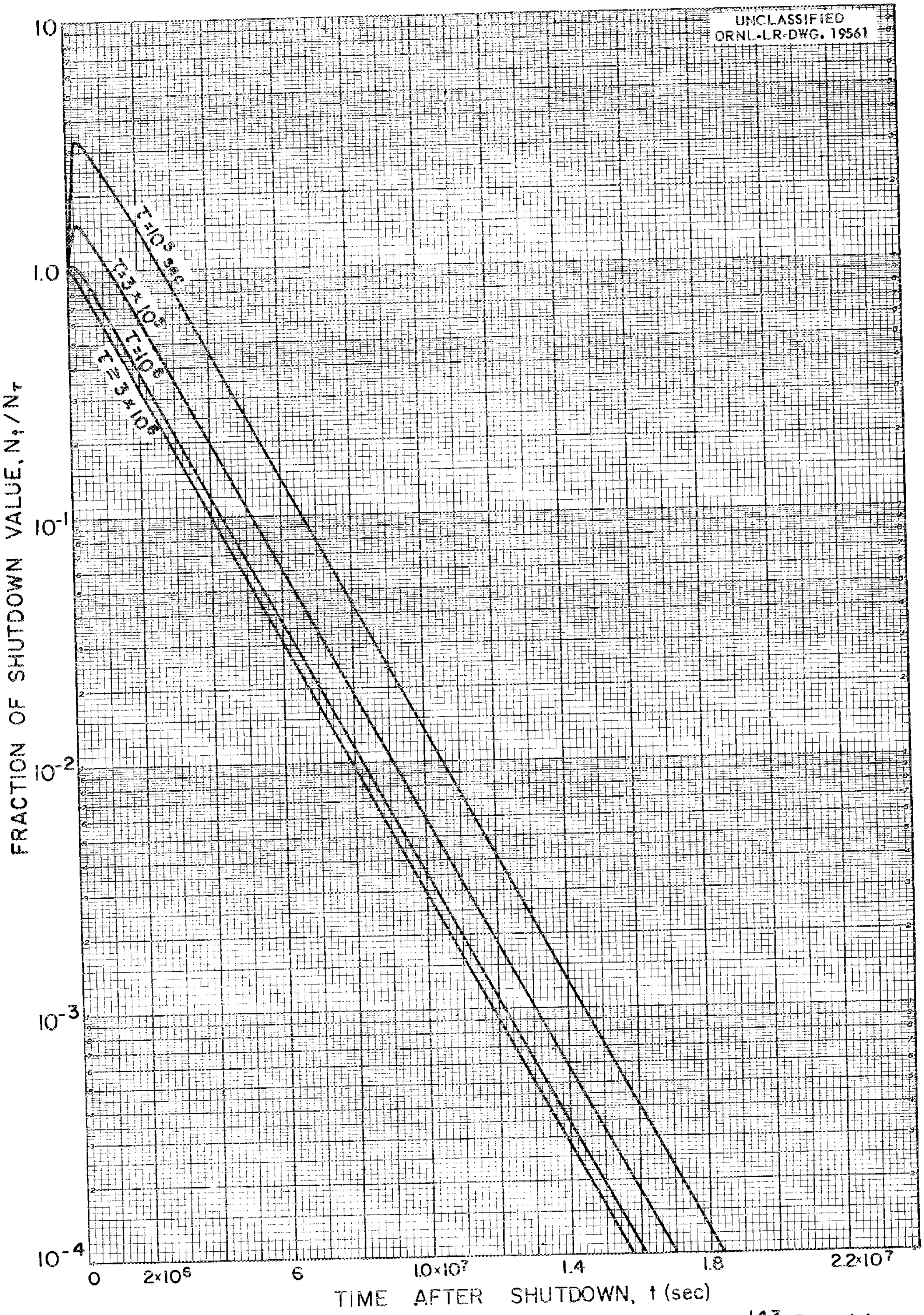

Fig. C-39. Fraction of Shutdown Value of 13.7d Pr^{143} Remaining at Various Times After Shutdown.

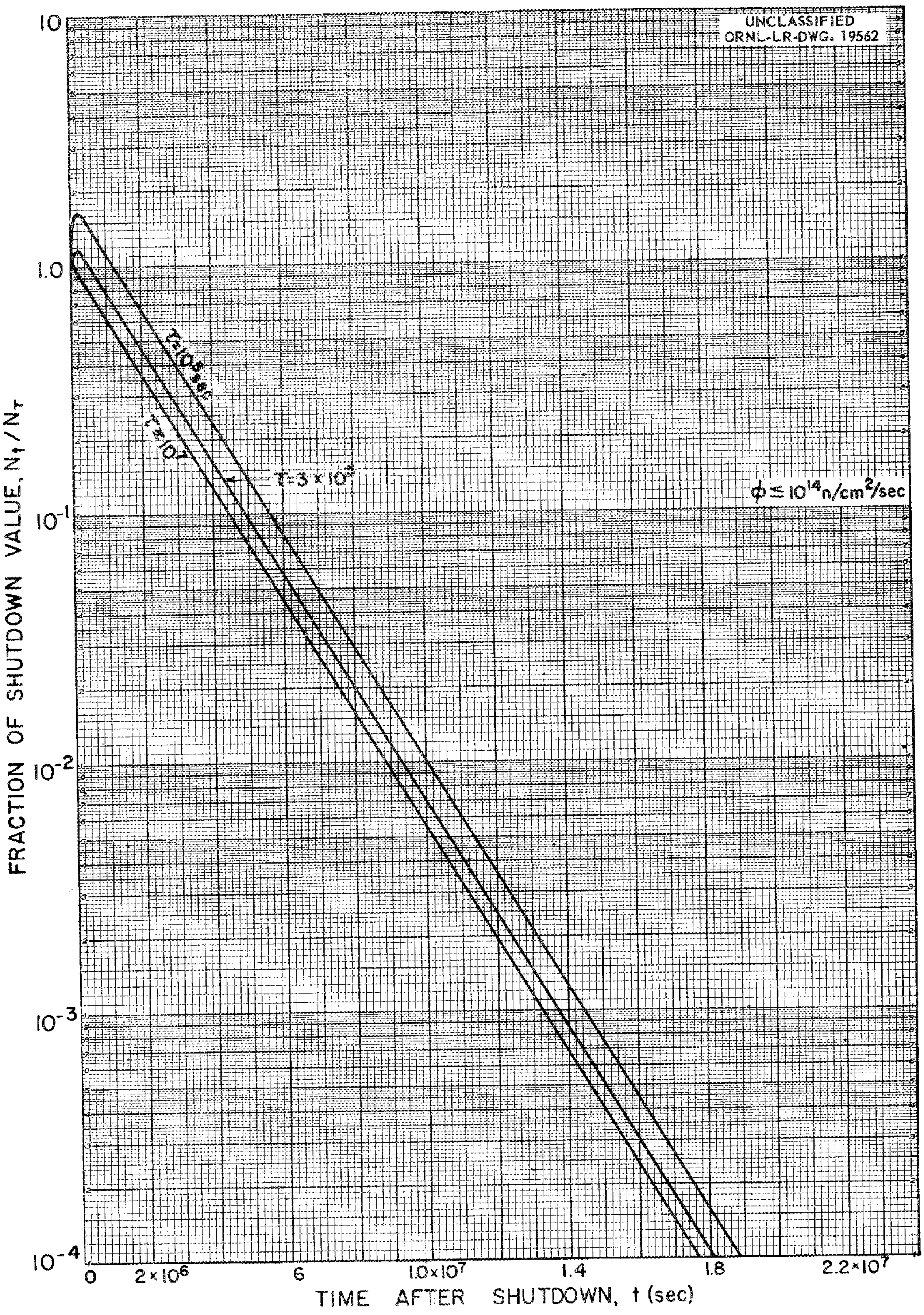

Fig. C-40. Fraction of Shutdown Value of 15.4d Eu^{156} Remaining at Various Times After Shutdown.

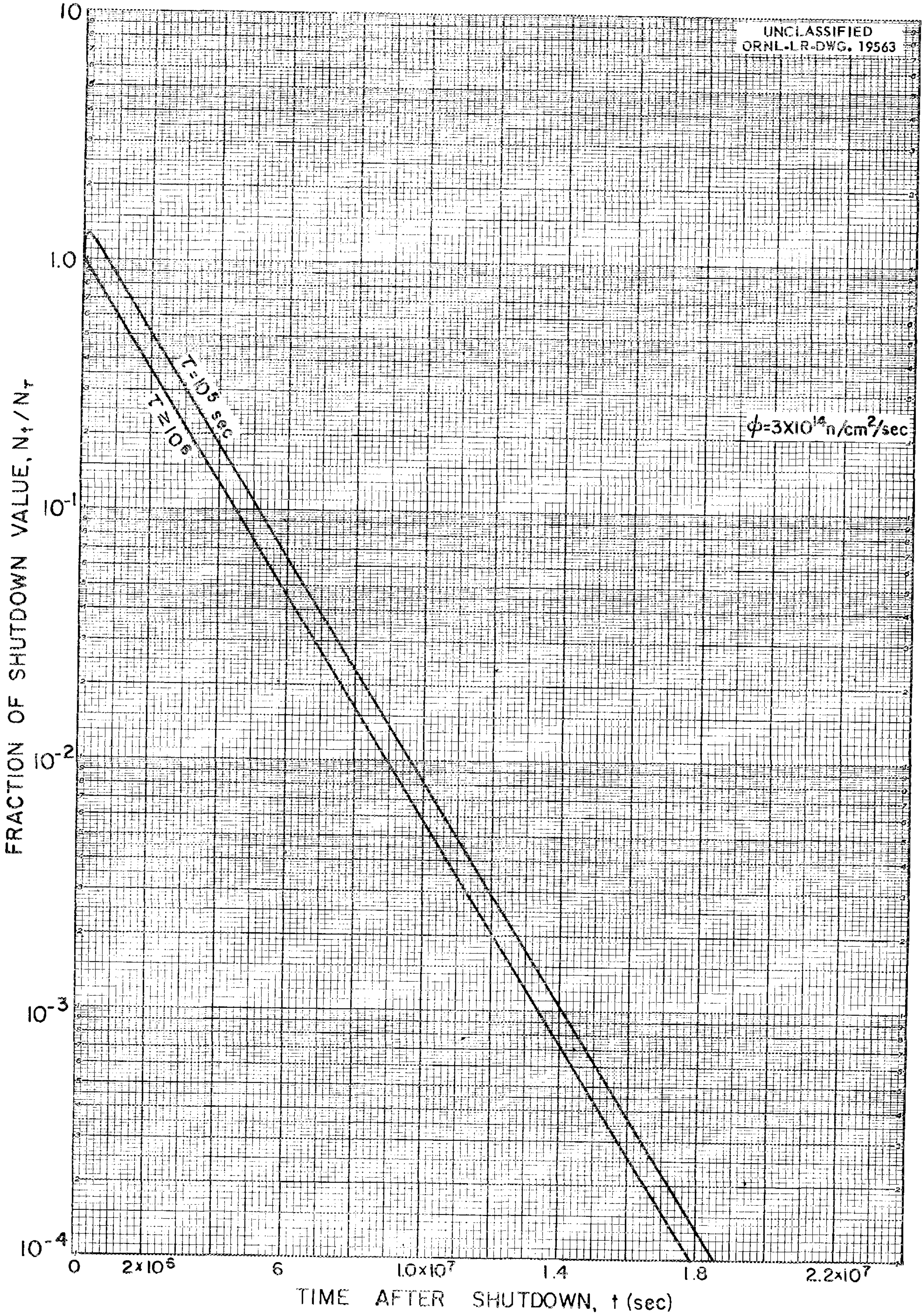

Fig. C-40a. Fraction of Shutdown Value of 15.4d Eu^{156} Remaining at Various Times After Shutdown.

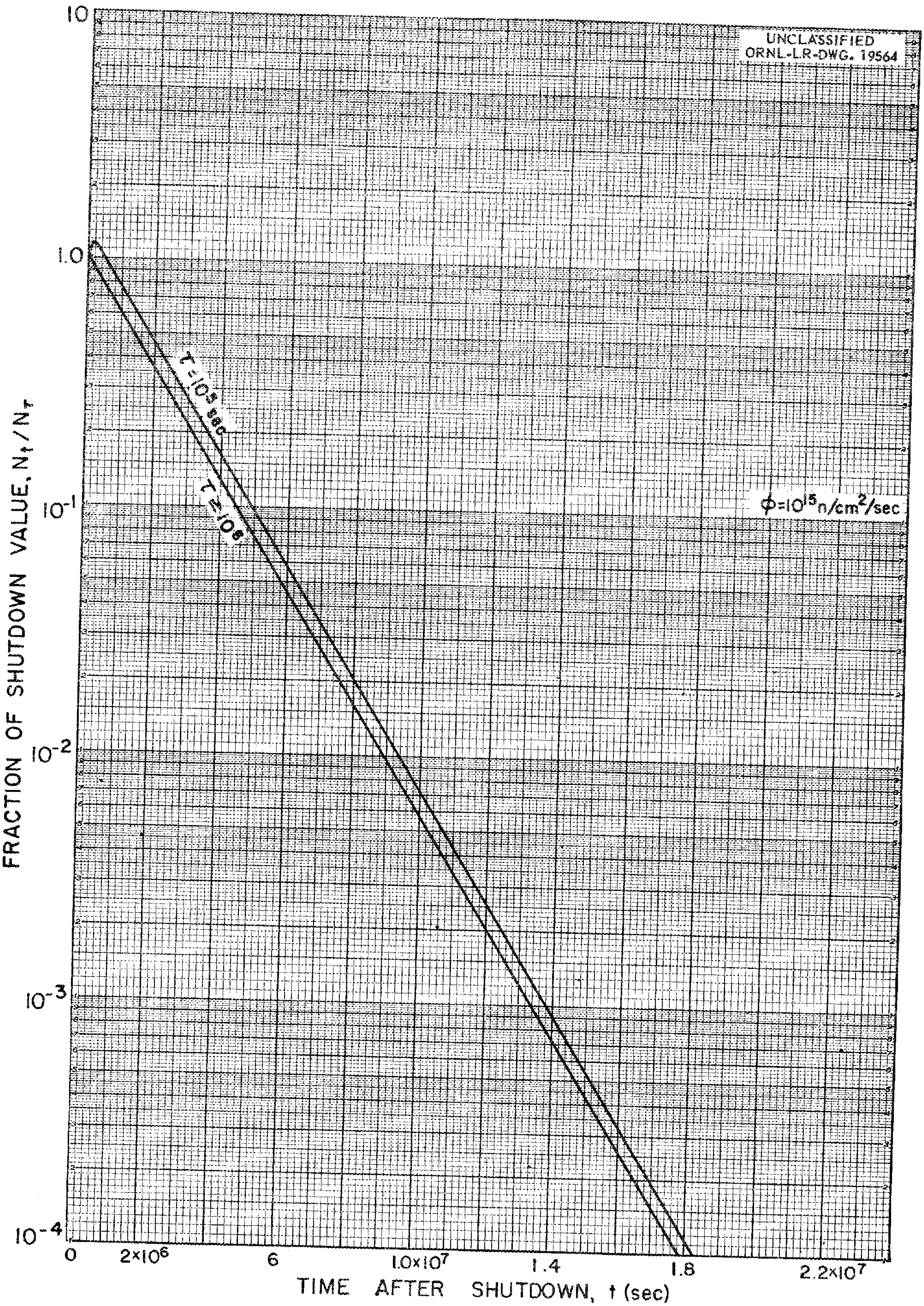

Fig. C-40b. Fraction of Shutdown Value of 15.4d Eu^{156} Remaining at Various Times After Shutdown.

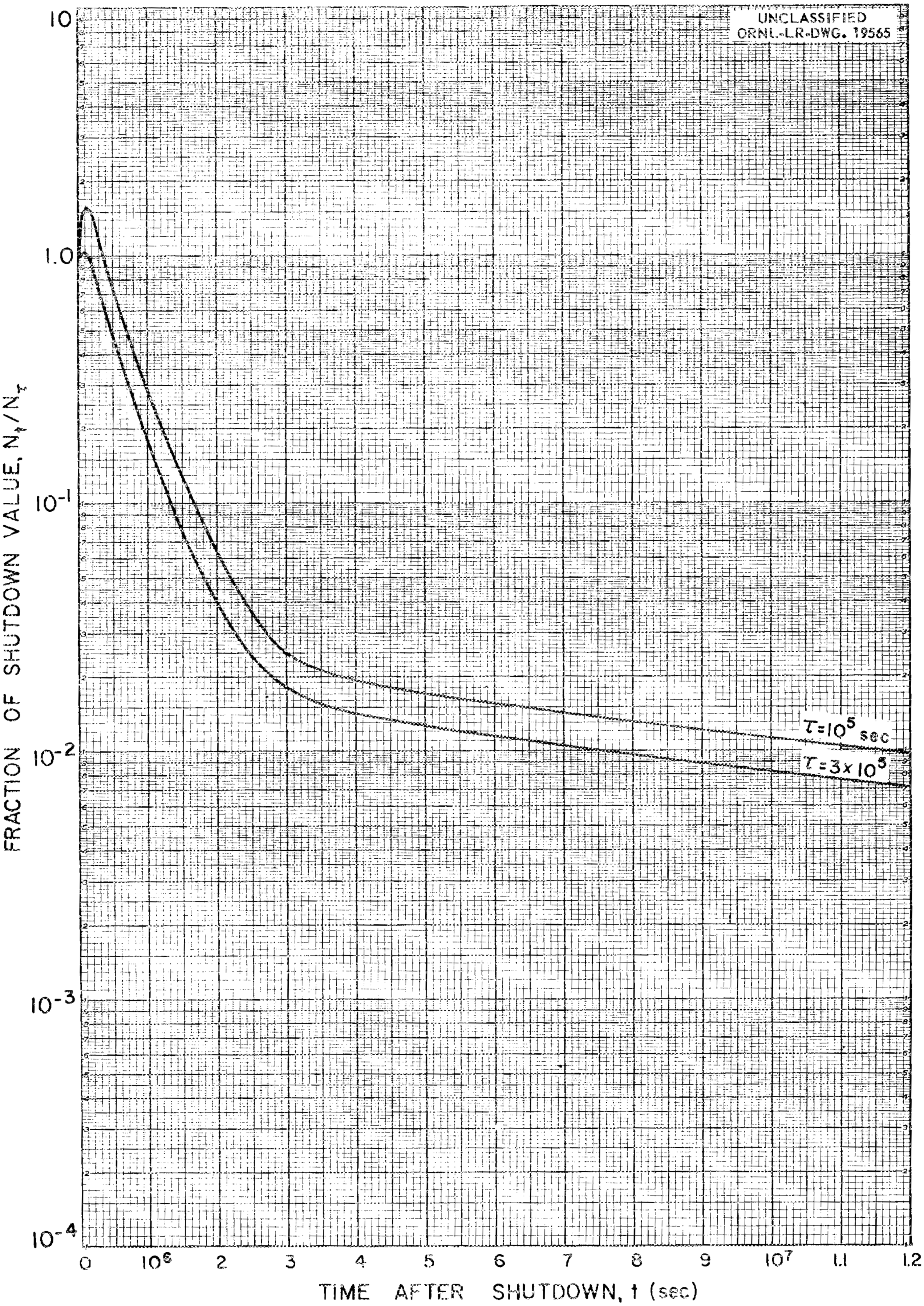

Fig. C-41. Fraction of Shutdown Value of 9.3 h Te^{127} Remaining at Various Times After Shutdown.

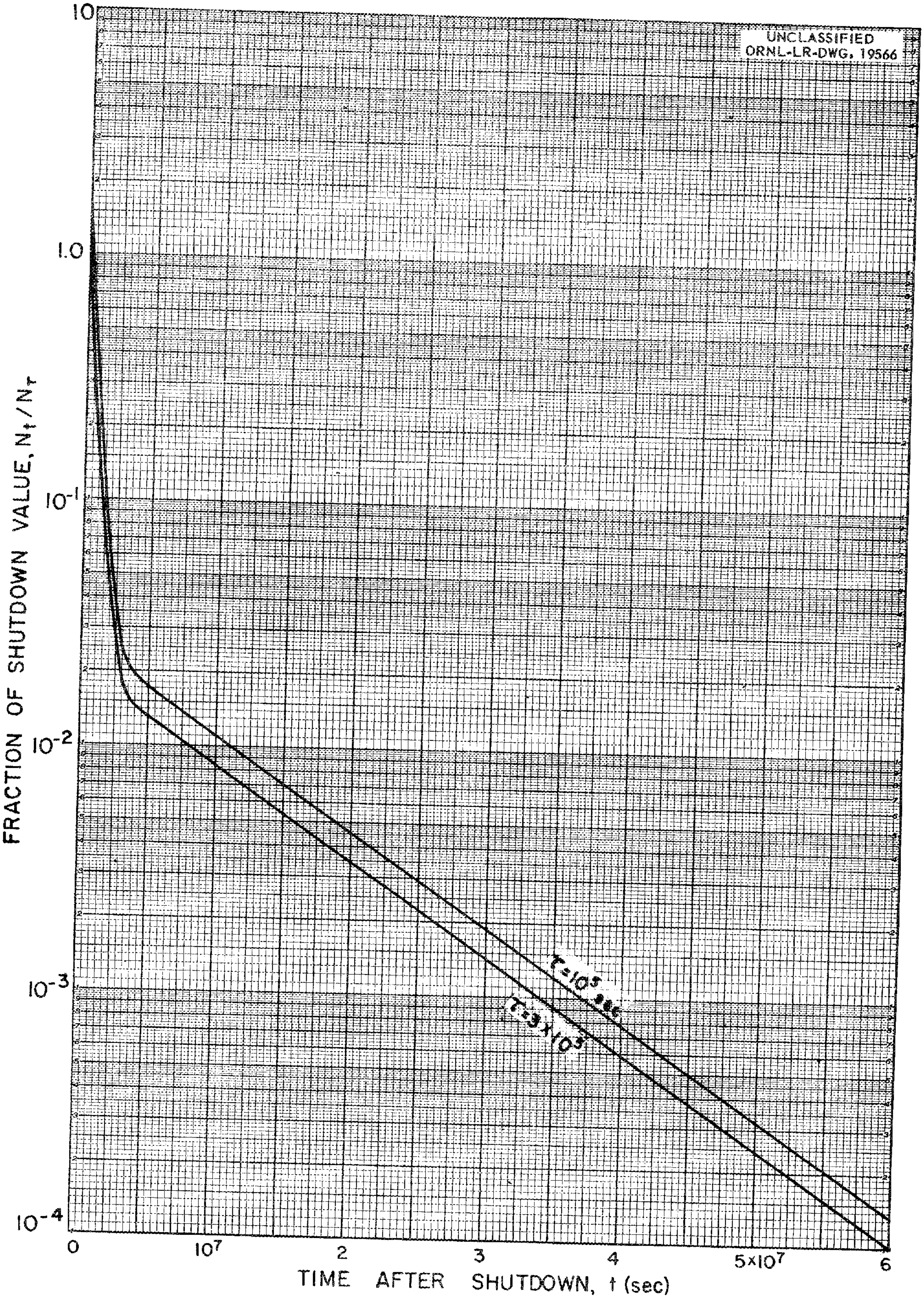

Fig. C-41a. Fraction of Shutdown Value of 9.3h Te^{127} Remaining at Various Times After Shutdown.

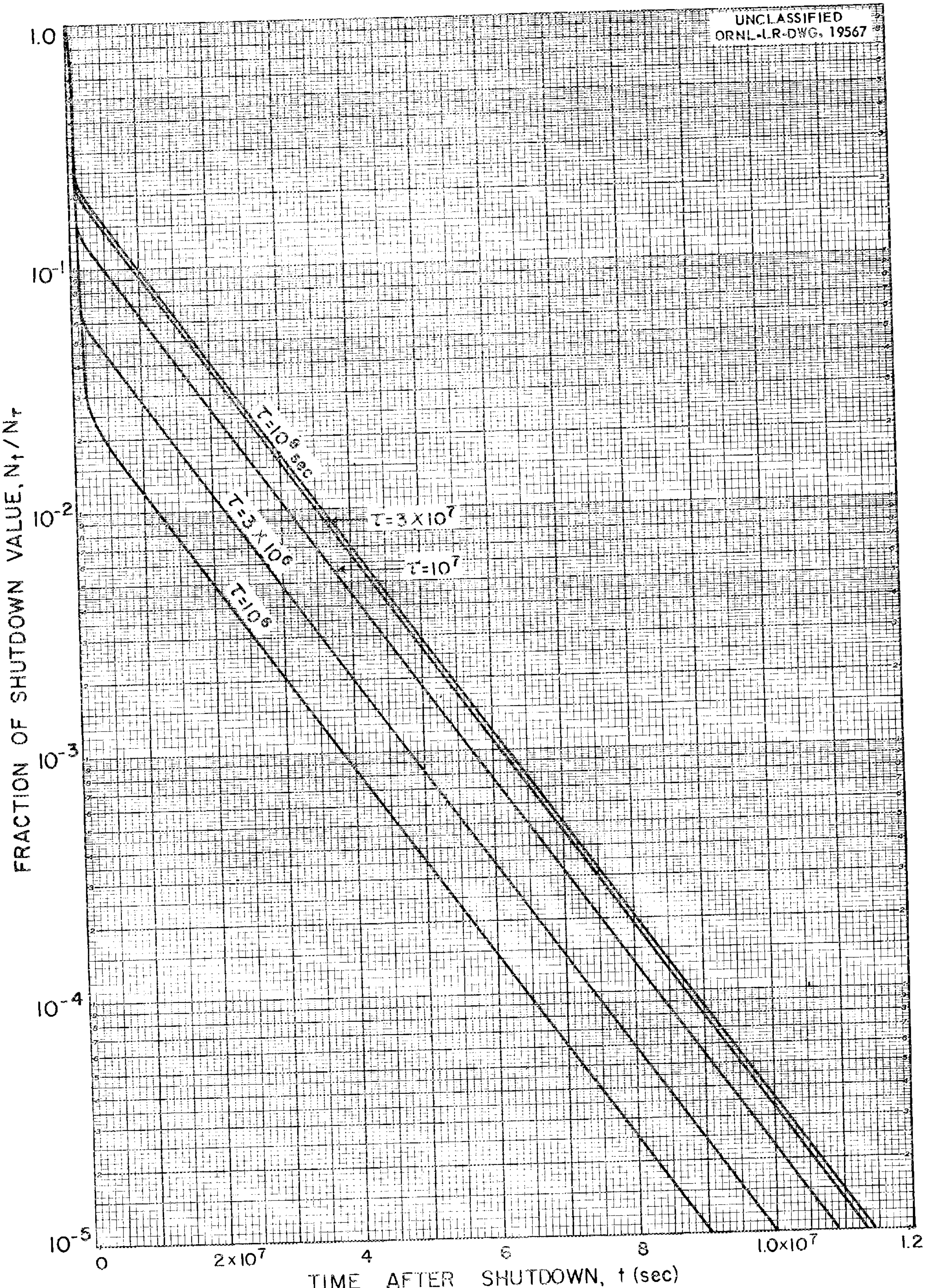

Fig. C-41b. Fraction of Shutdown Value of 9.3h Te ^{127} Remaining at Various Times After Shutdown.

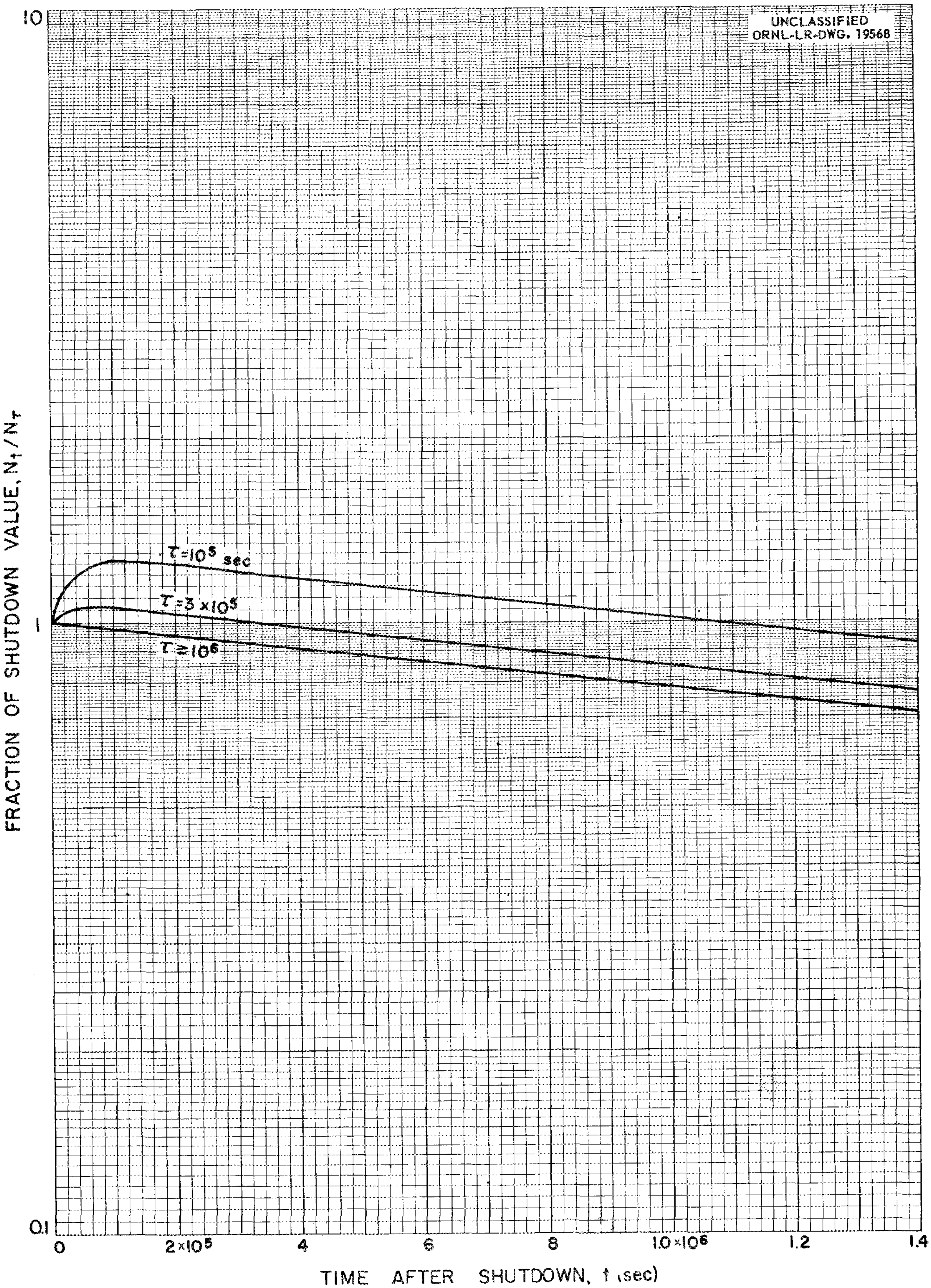

Fig. C-42. Fraction of Shutdown Value of 33d Te^{129m} Remaining at Various Times After Shutdown.

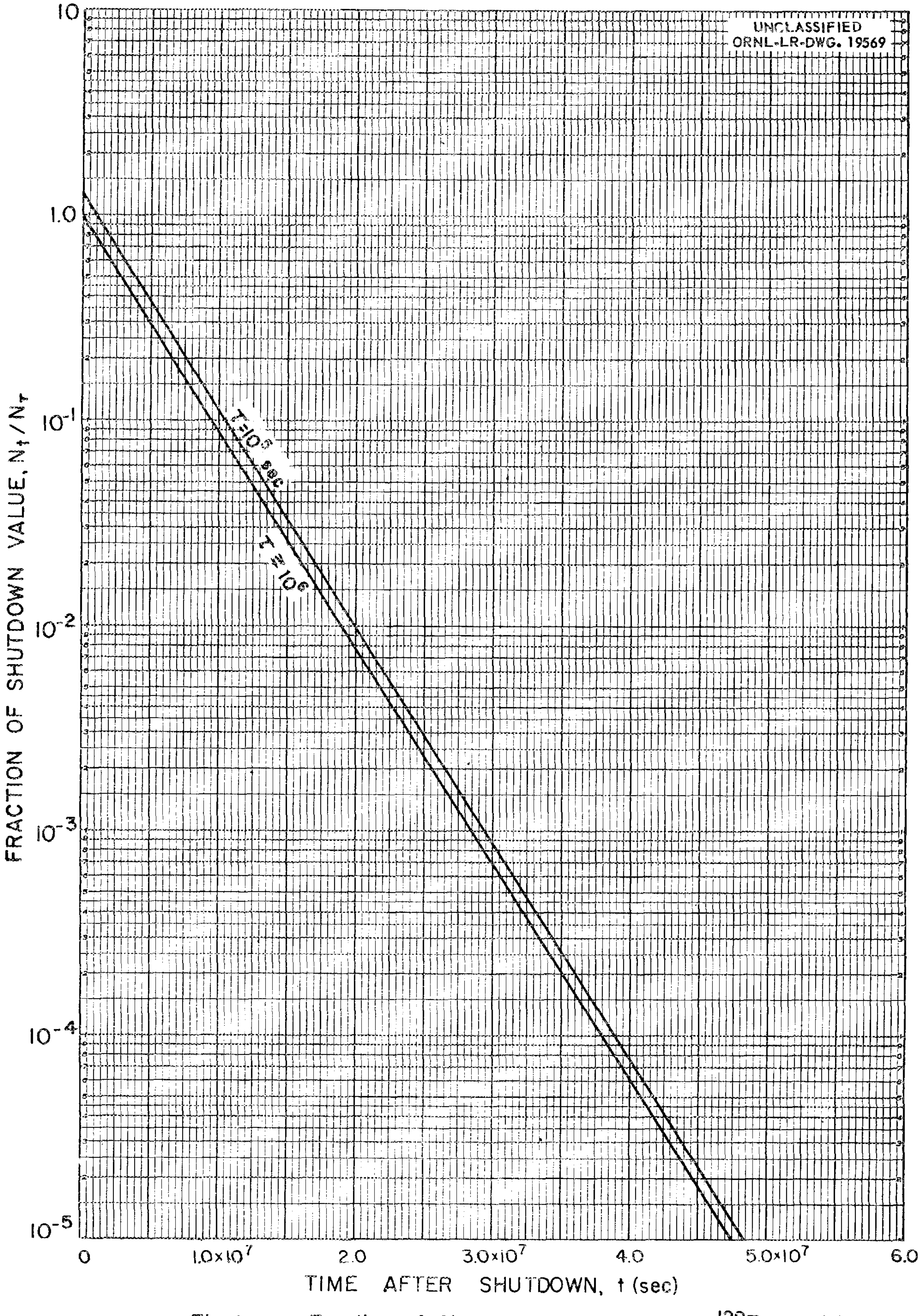

Fig. C-42a. Fraction of Shutdown Value of 33d Te^{129m} Remaining at Various Times After Shutdown.

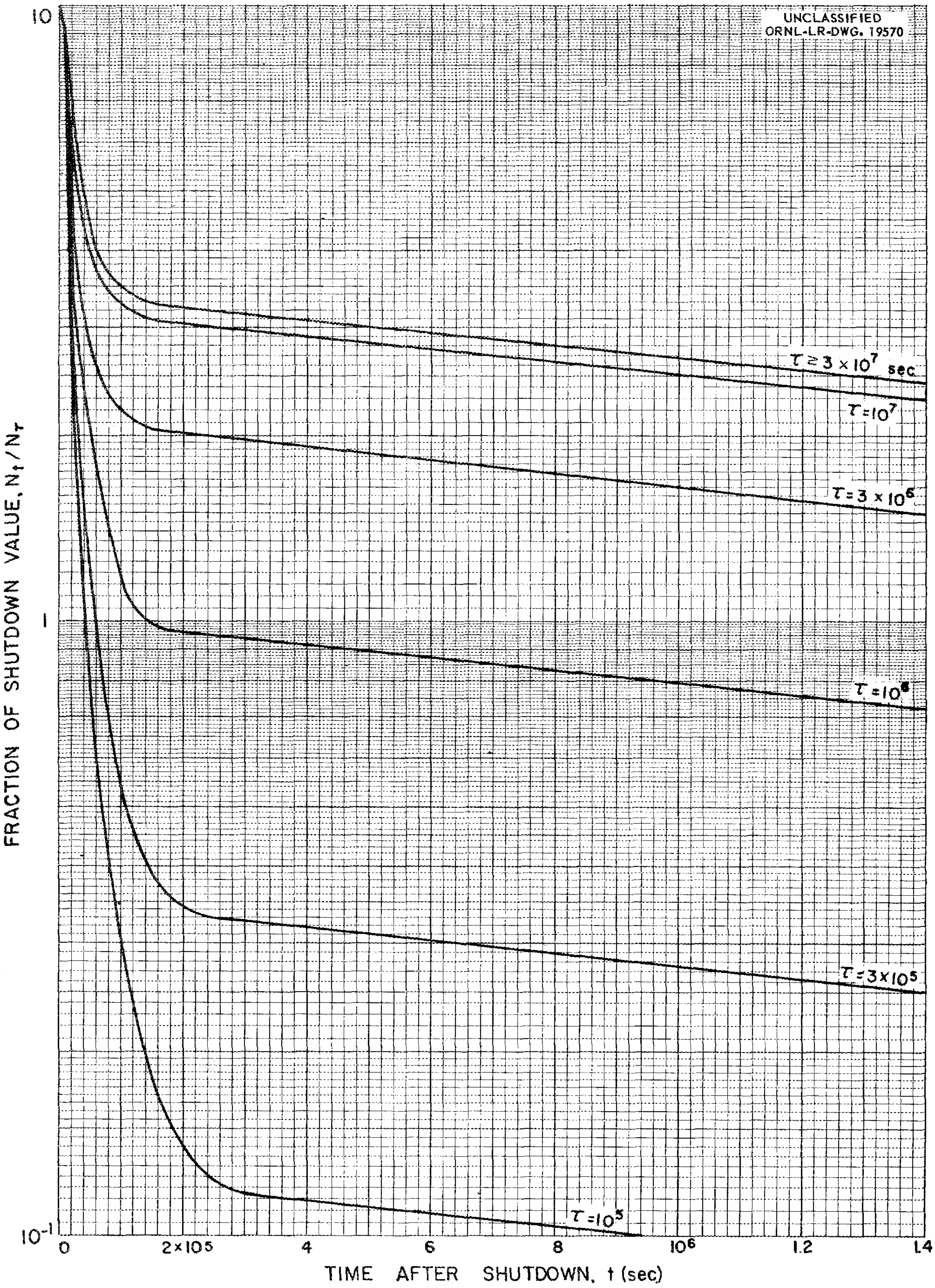

Fig. C-43. Fraction of Shutdown Value of 72m Te^{129} Remaining at Various Times After Shutdown.

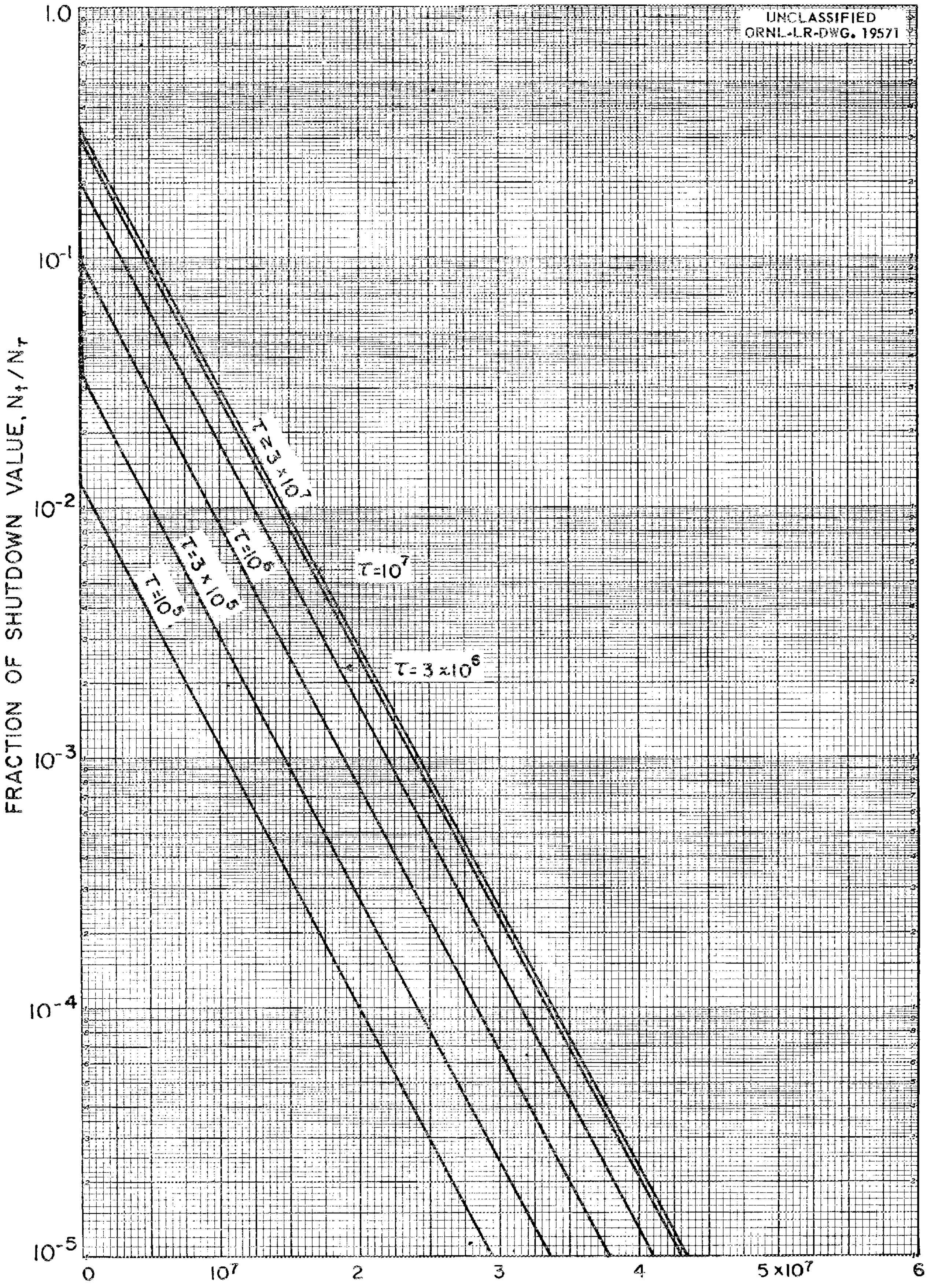

Fig. C-43a. Fraction of Shutdown Value of 72m Te^{129} Remaining at Various Times After Shutdown.

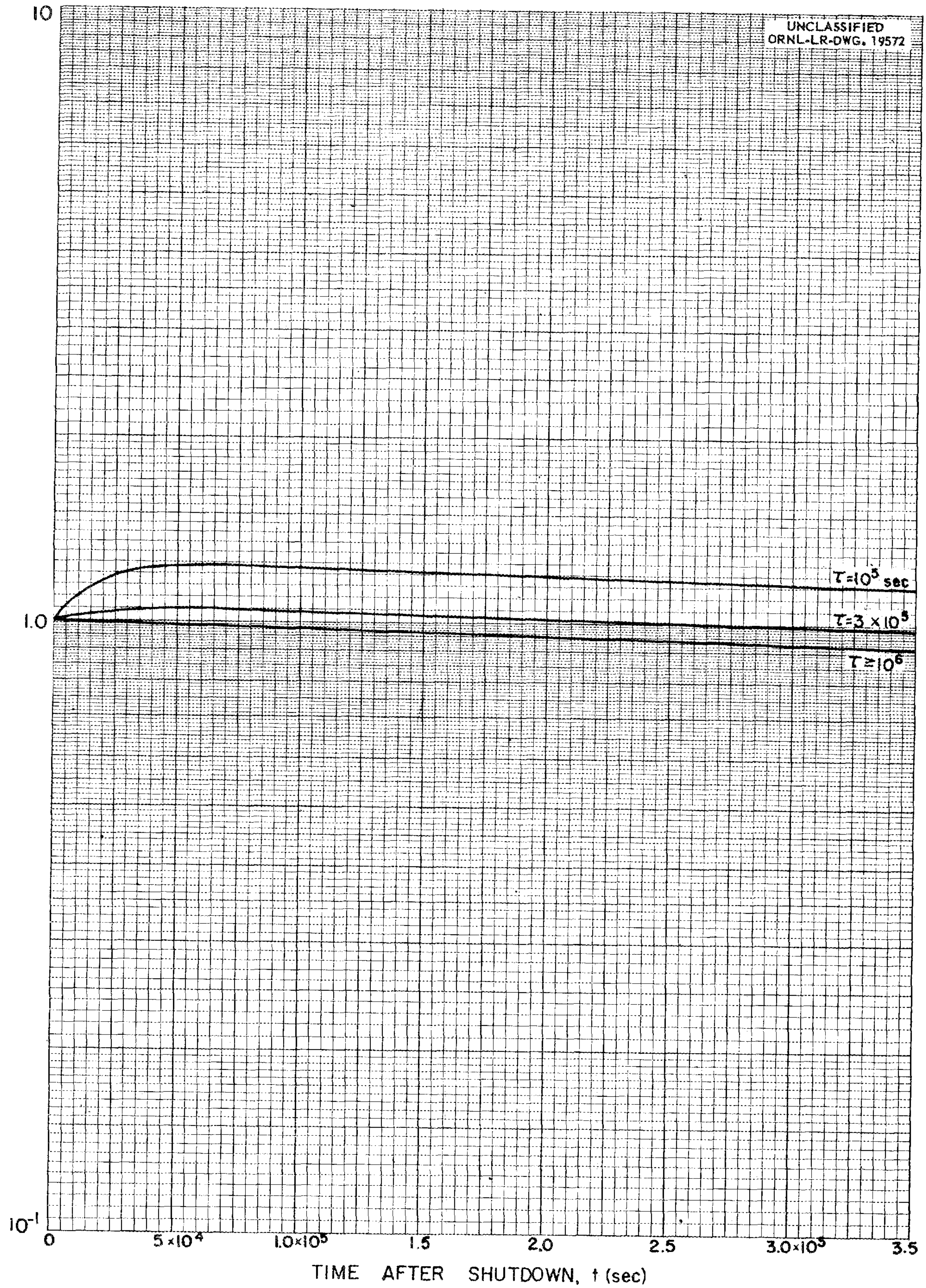

Fig. C-44. Fraction of Shutdown Value of 32d Ce^{141} Remaining at Various Times After Shutdown.

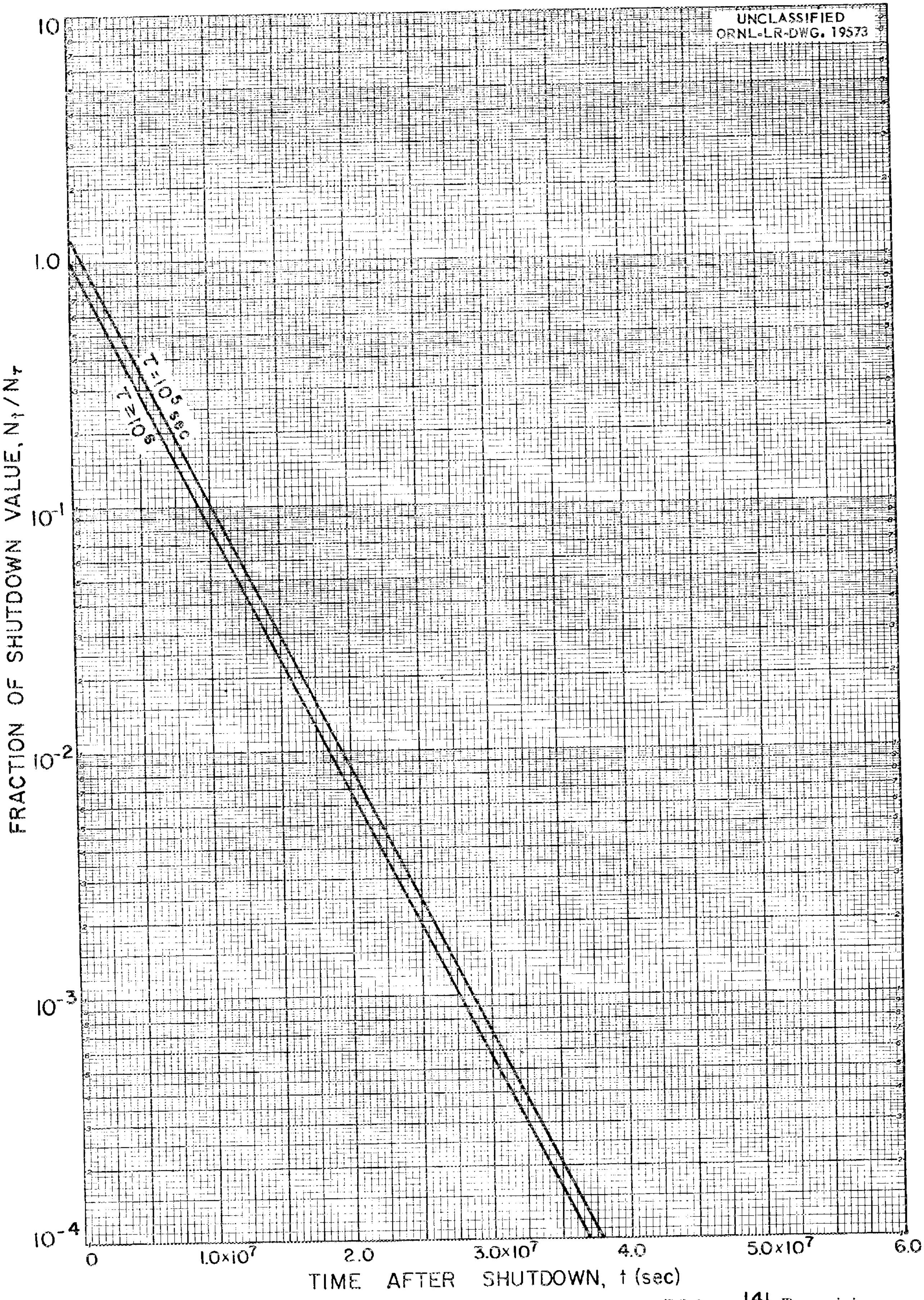

Fig. C-44a. Fraction of Shutdown Value of 32d Ce^{141} Remaining at Various Times After Shutdown.

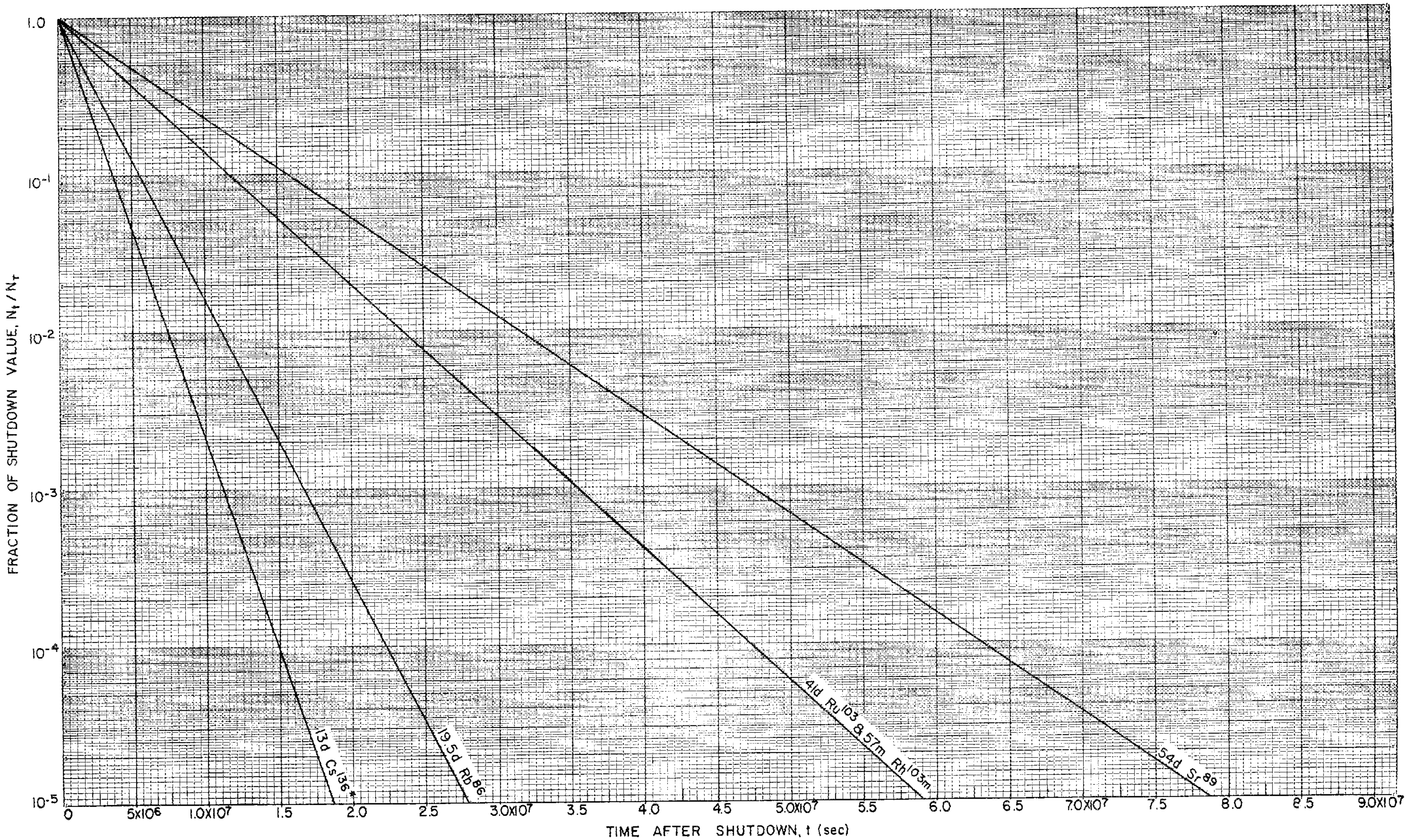

Fig. C-45. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

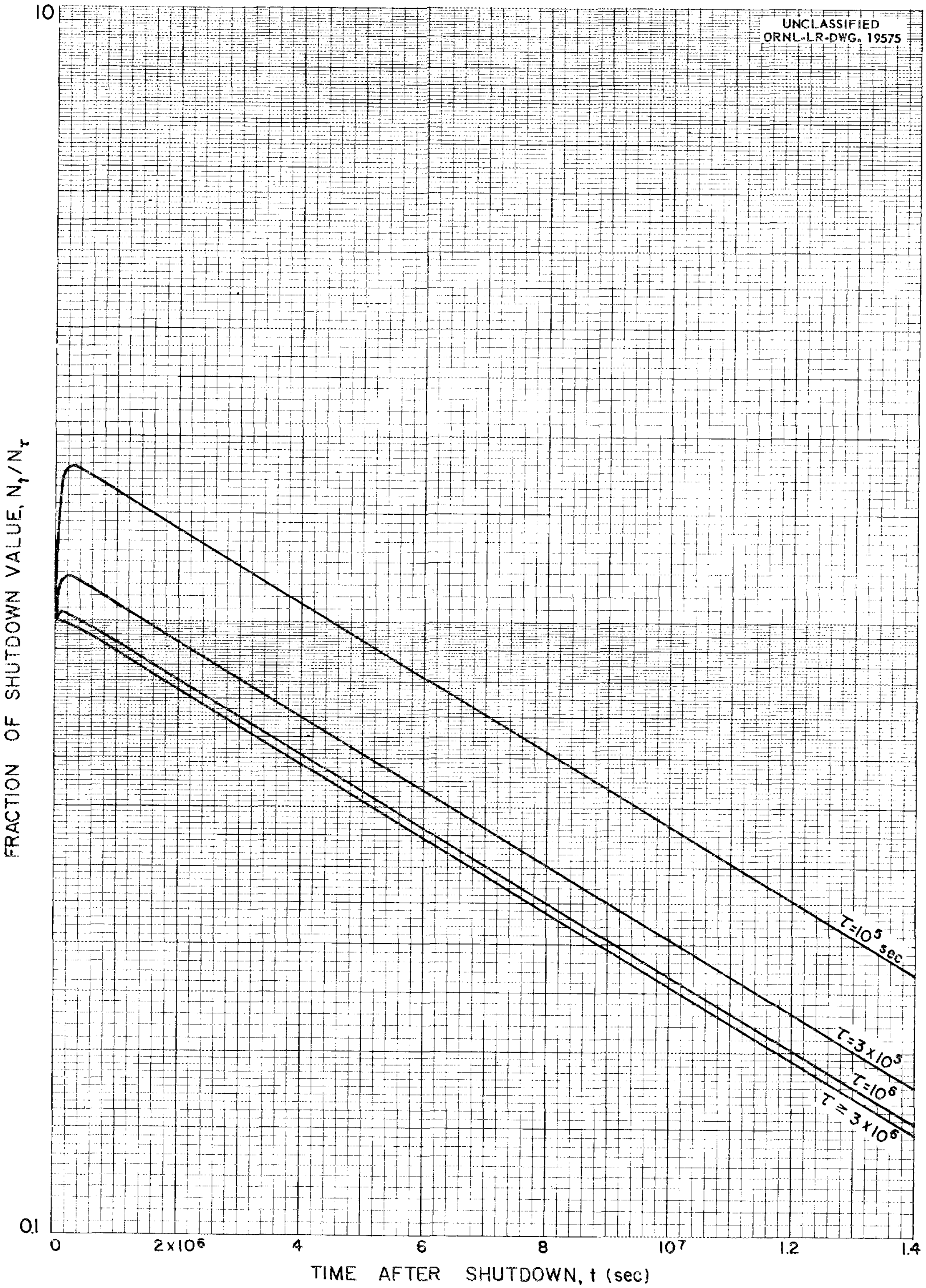

Fig. C-46. Fraction of Shutdown Value of 58d Y^{91} Remaining at Various Times After Shutdown.

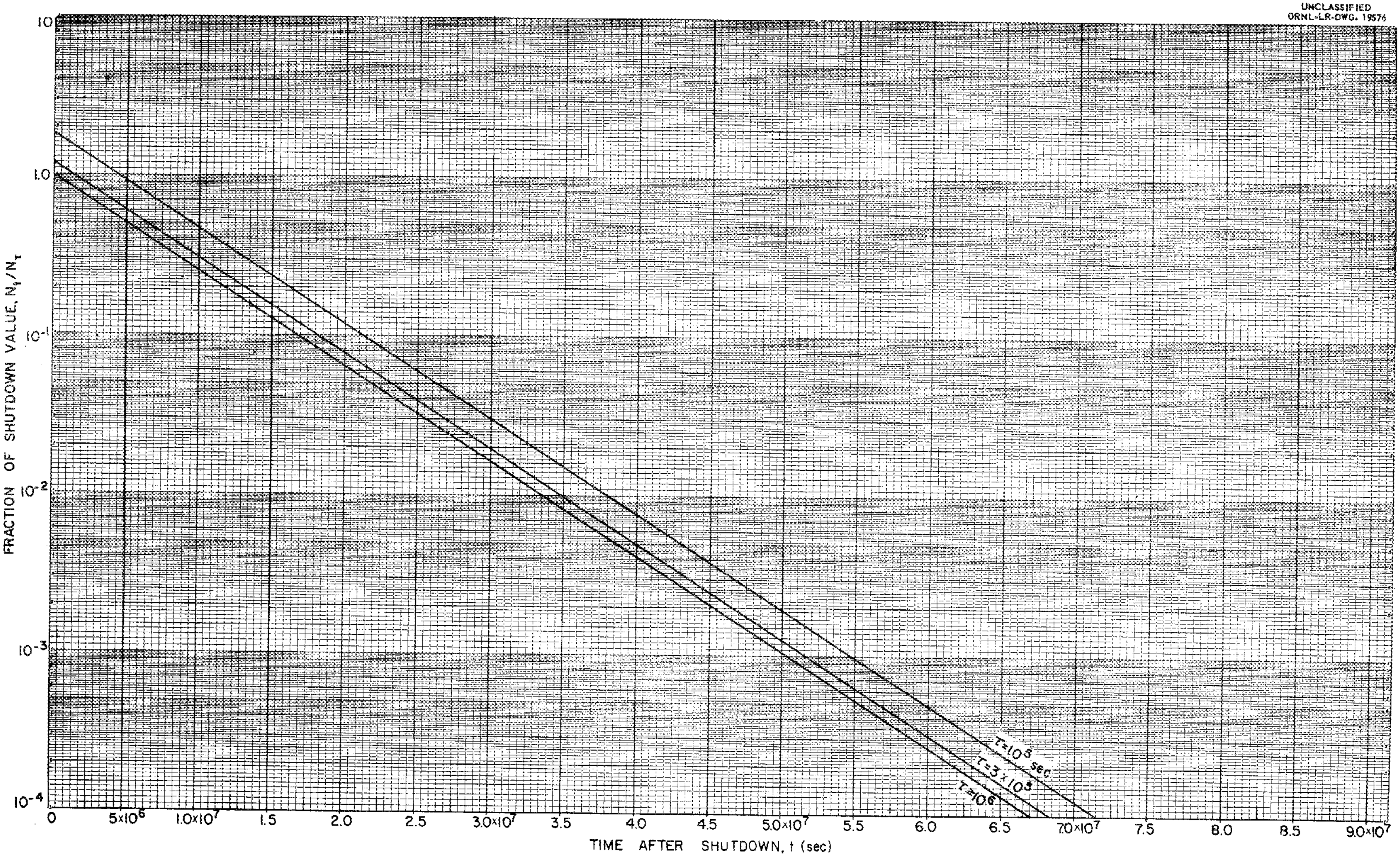

Fig. C-46a. Fraction of Shutdown Value of 58d Y^{91} Remaining at Various Times After Shutdown.

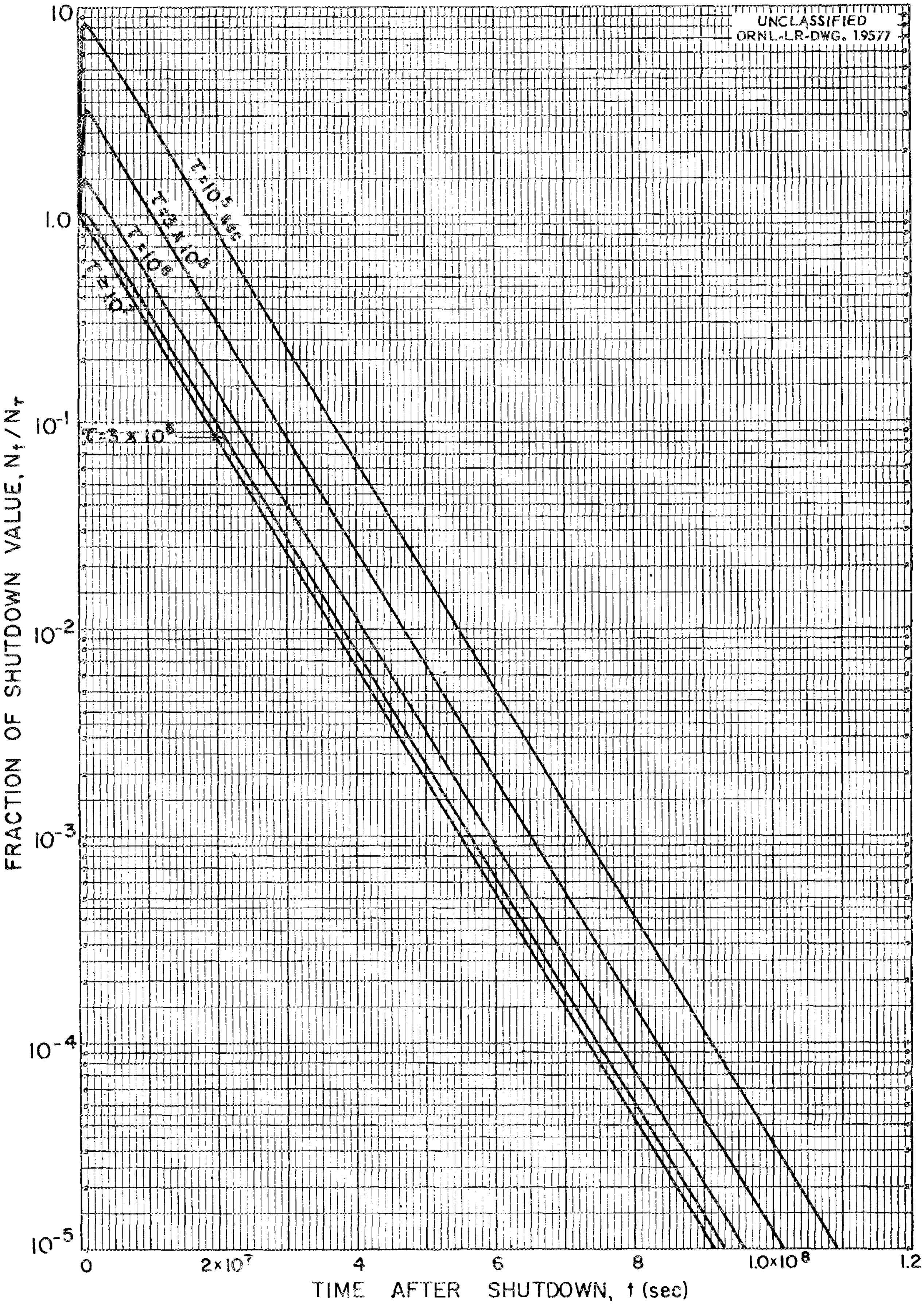

Fig. C-47. Fraction of Shutdown Value of 90h Nb^{95m} Remaining at Various Times After Shutdown.

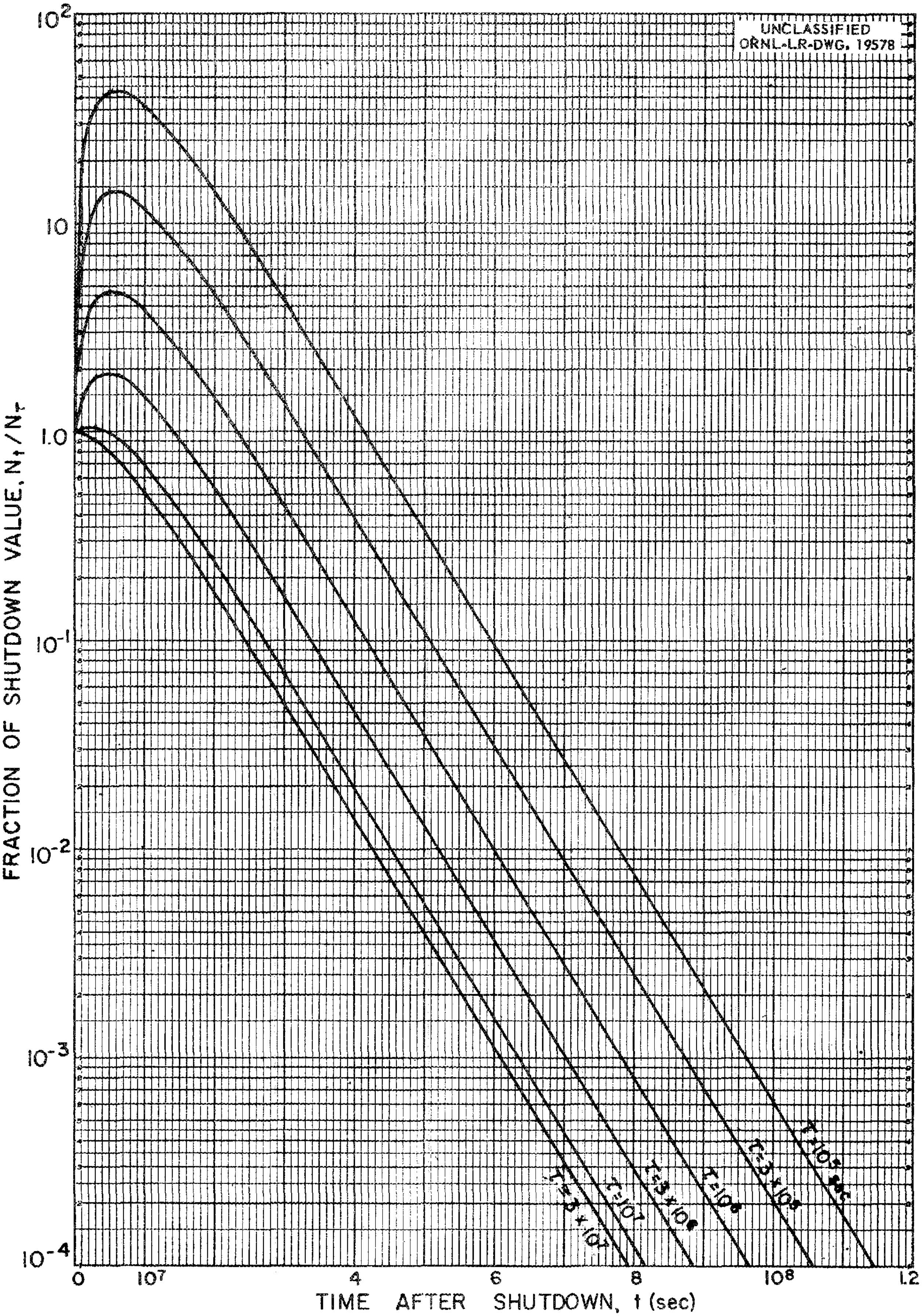

Fig. C-48. Fraction of Shutdown Value of 35d Nb^{95} Remaining at Various Times After Shutdown.

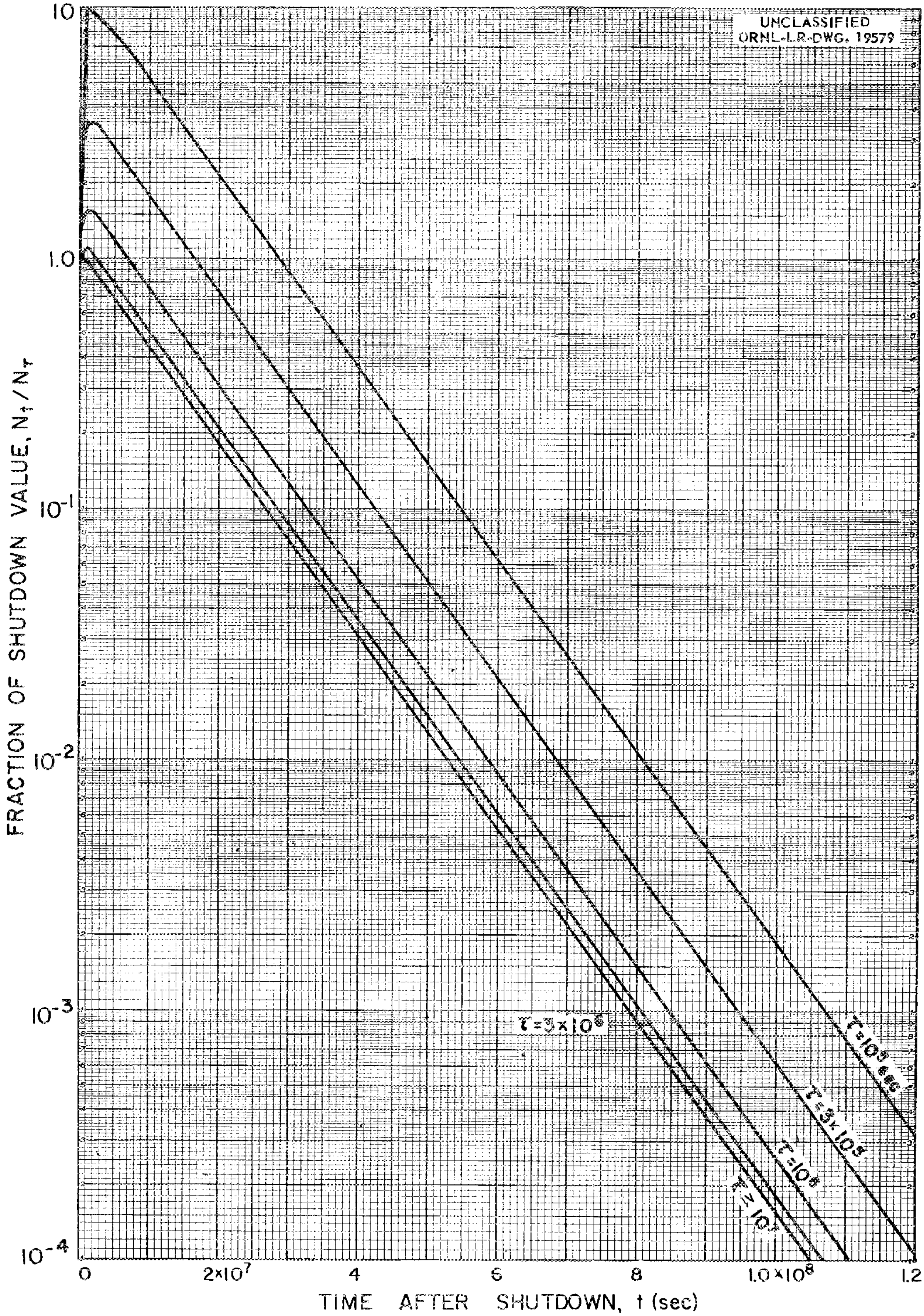

Fig. C-49. Fraction of Shutdown Value of 90 d Te^{127m} Remaining at Various Times After Shutdown.

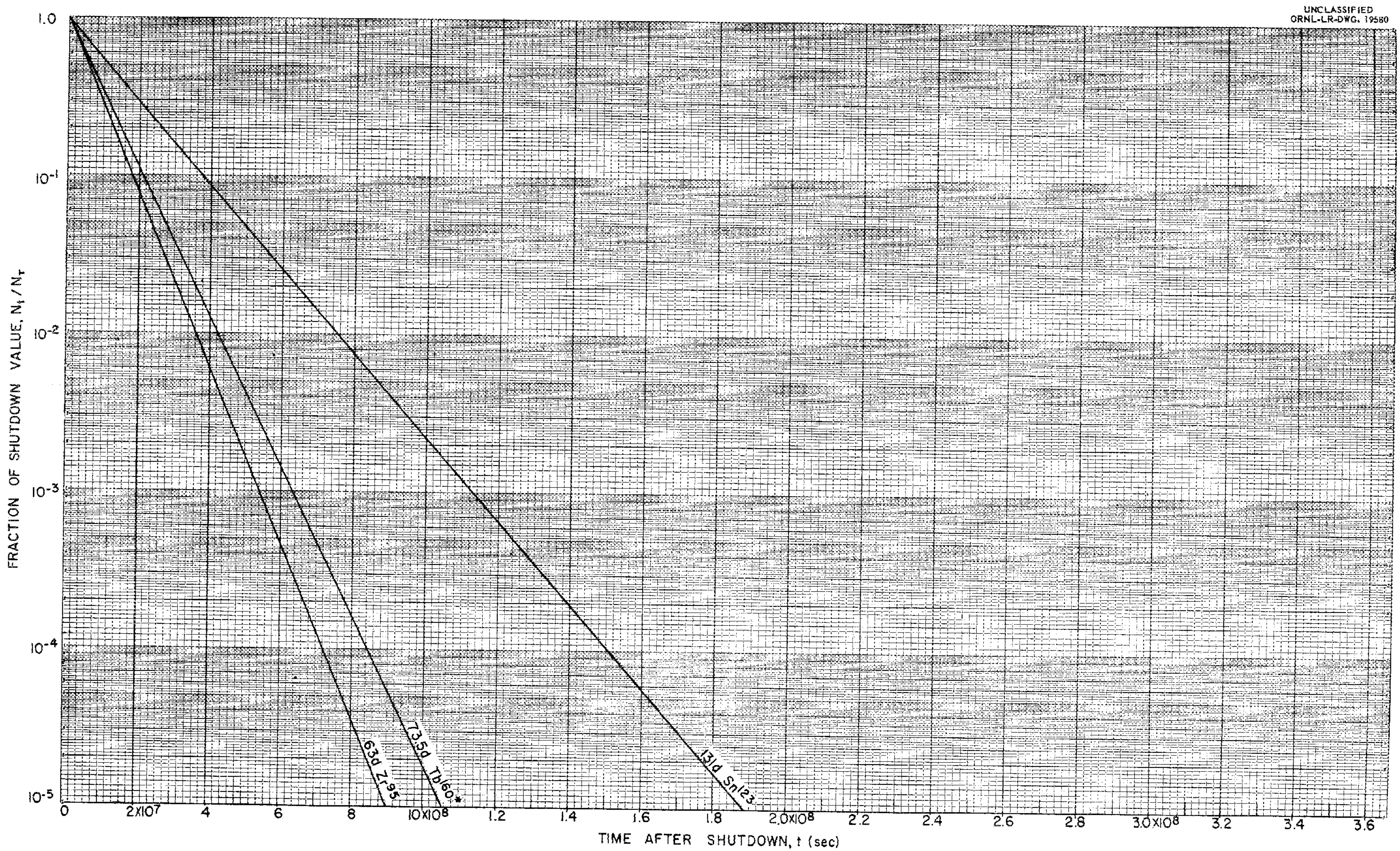

Fig. C-50. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

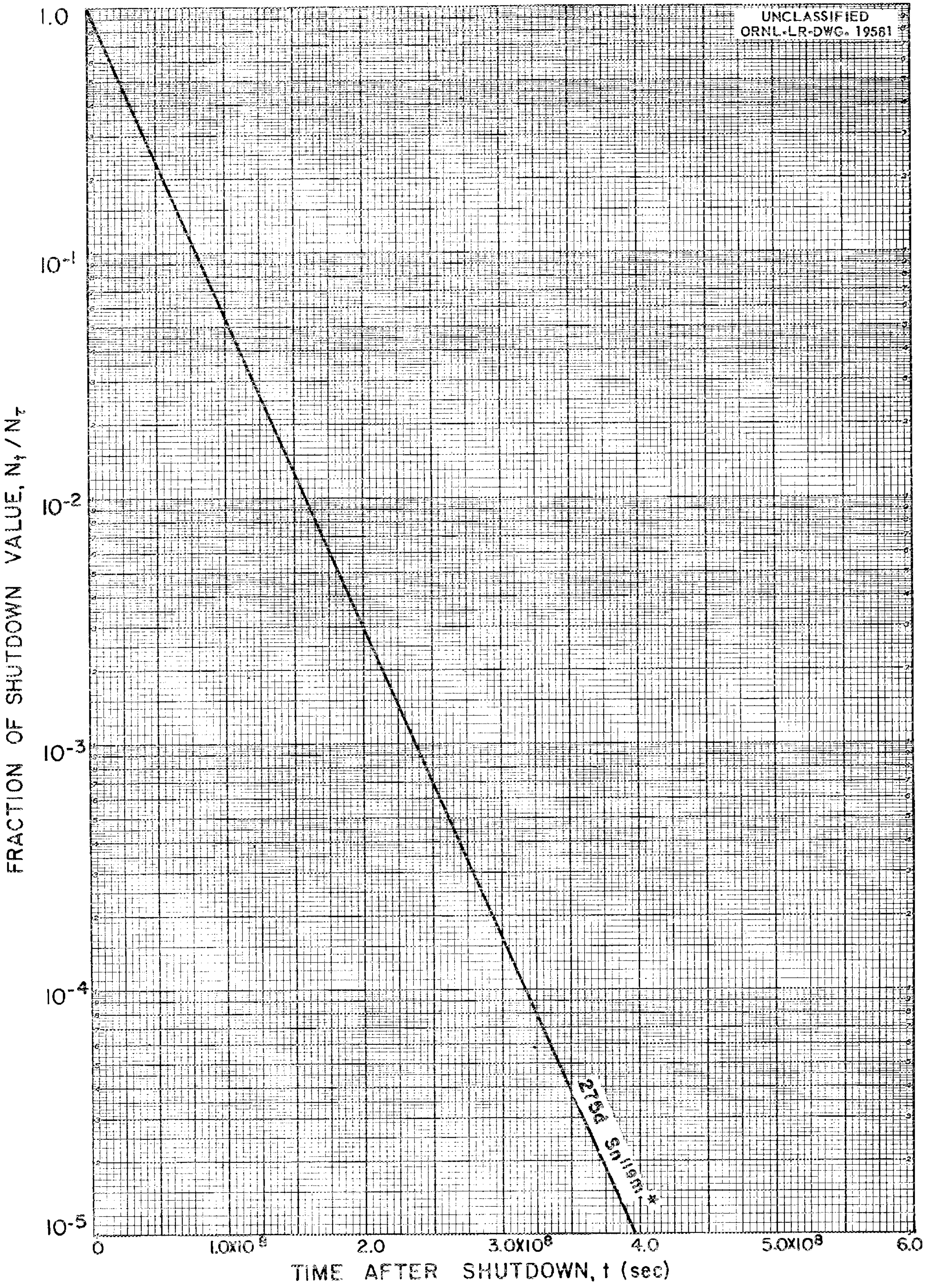

Fig. C-51. Fraction of Shutdown Value of 275d Sn^{119m*} Remaining at Various Times After Shutdown.

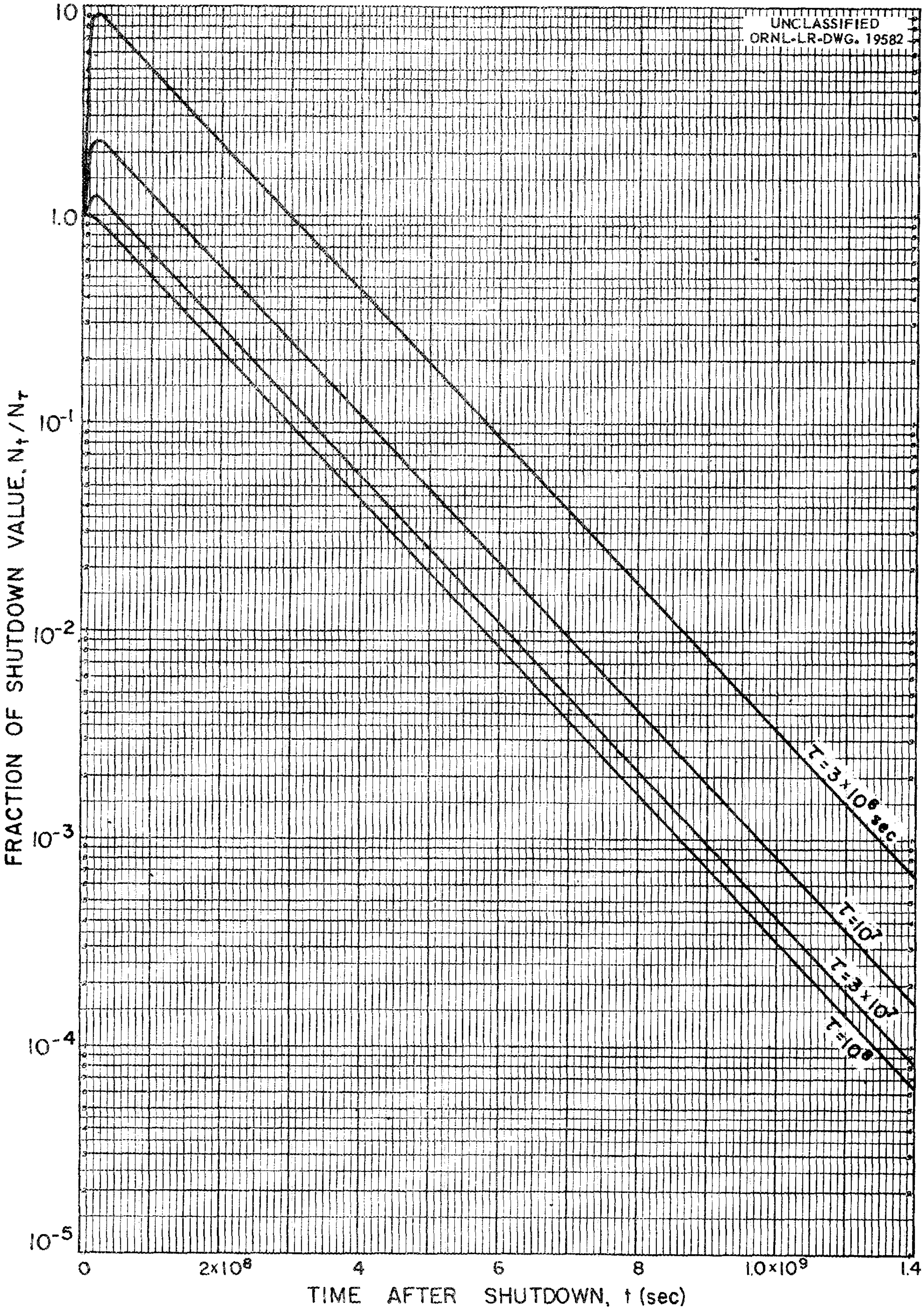

Fig. C-52. Fraction of Shutdown Value of 58d Te^{125m} Remaining at Various Times After Shutdown.

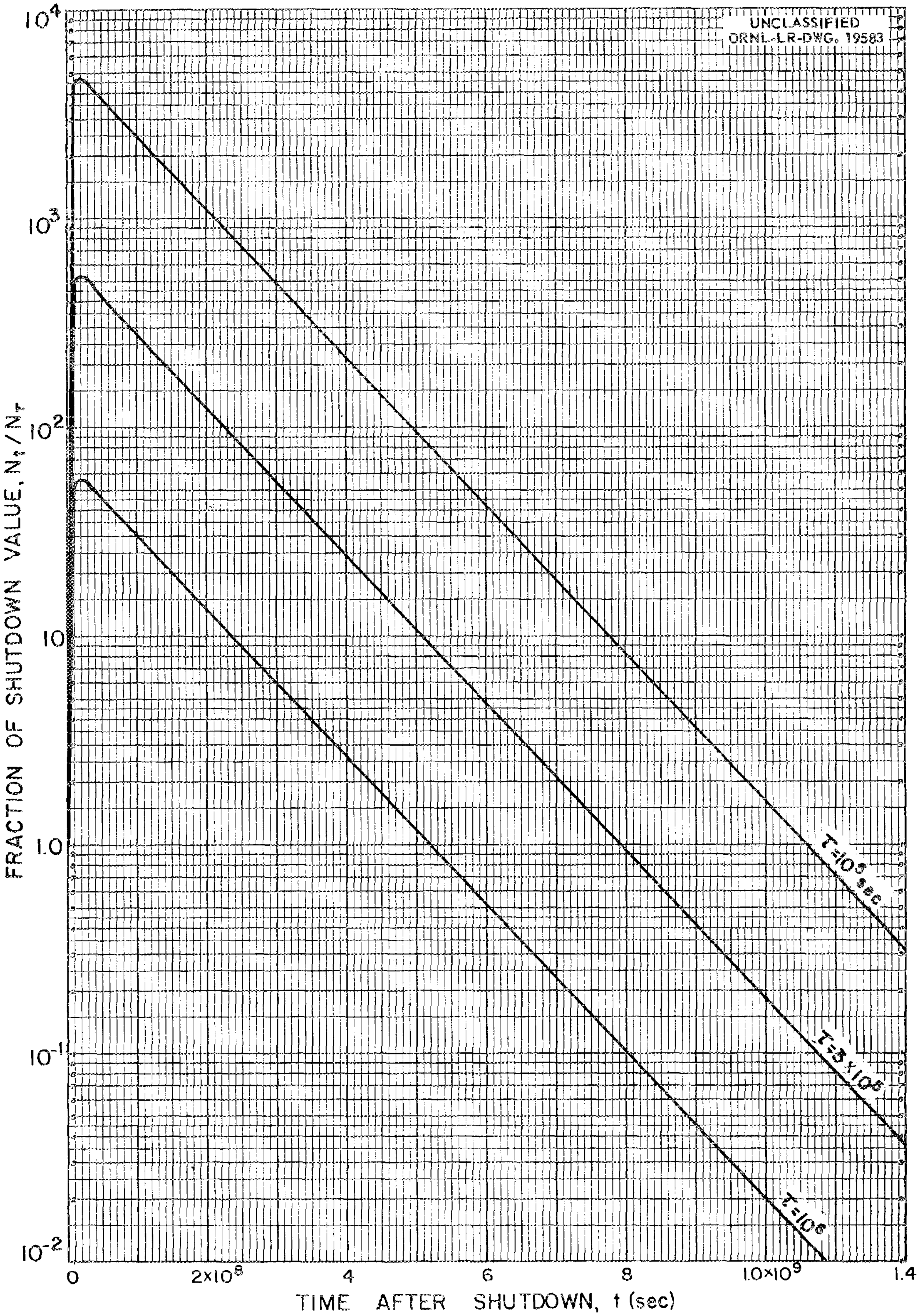

Fig. C-52a. Fraction of Shutdown Value of 58d Te^{125m} Remaining at Various Times After Shutdown.

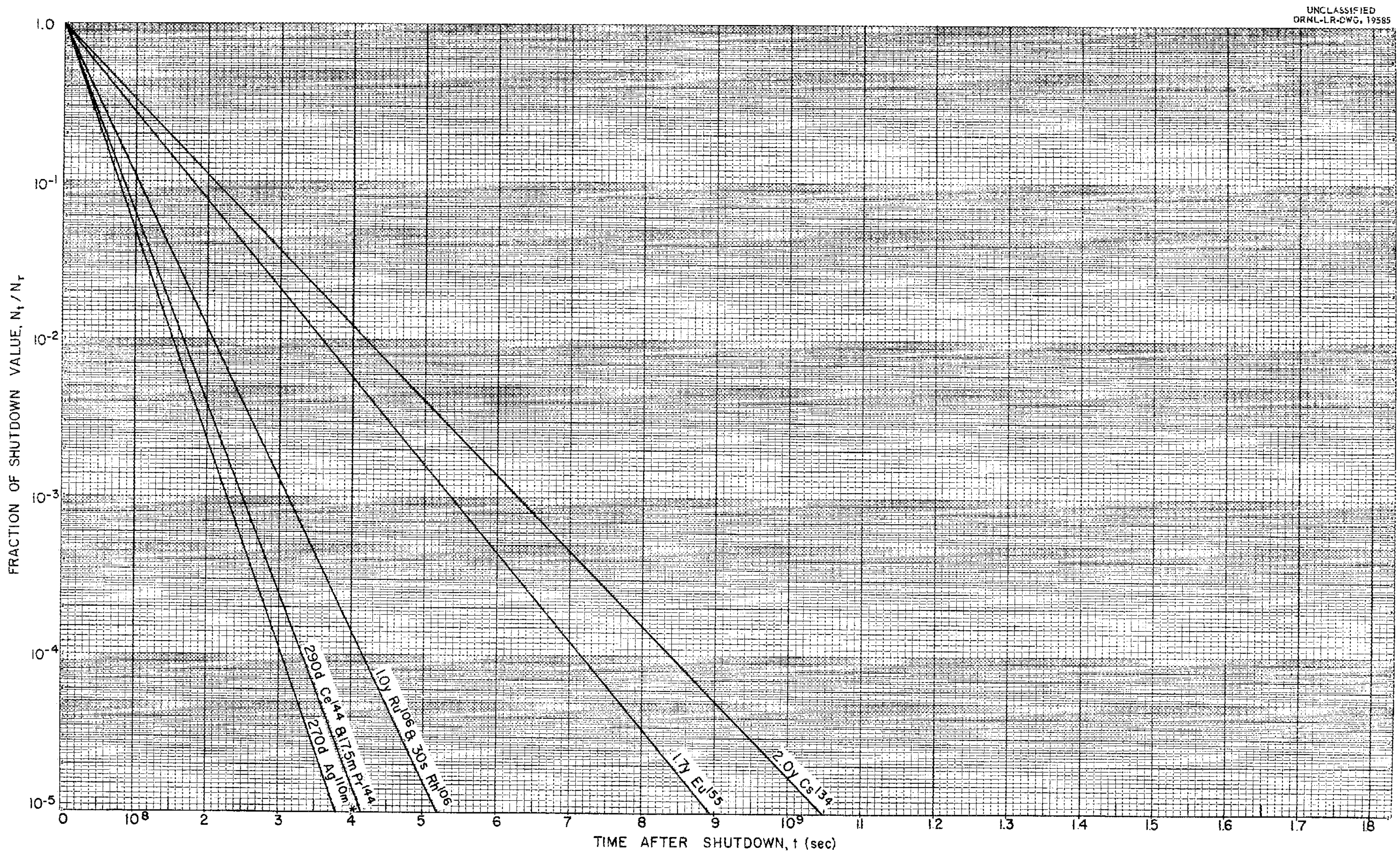

Fig. C-53. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

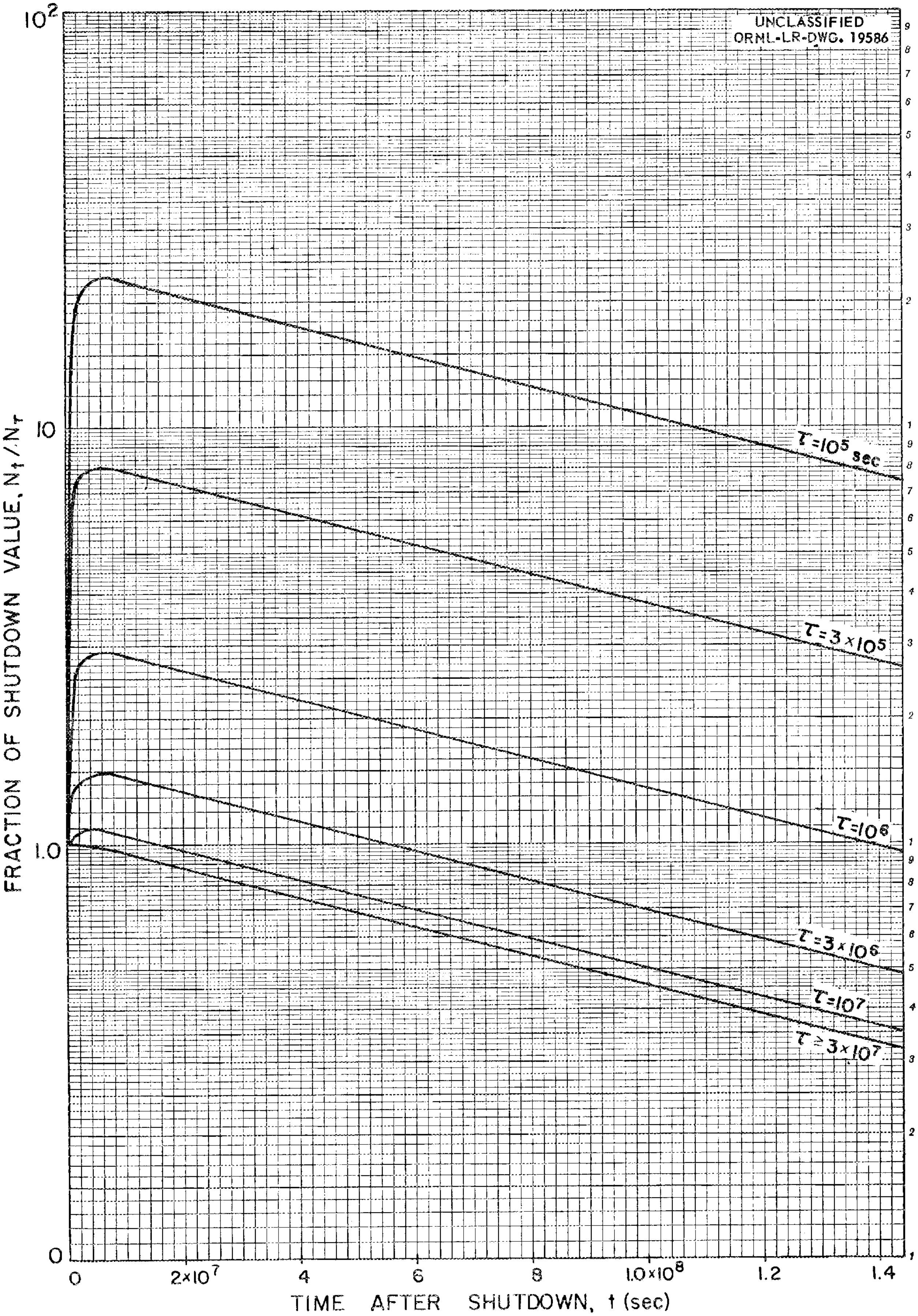

Fig. C-54. Fraction of Shutdown Value of 2.7y Sb^{125} Remaining at Various Times After Shutdown.

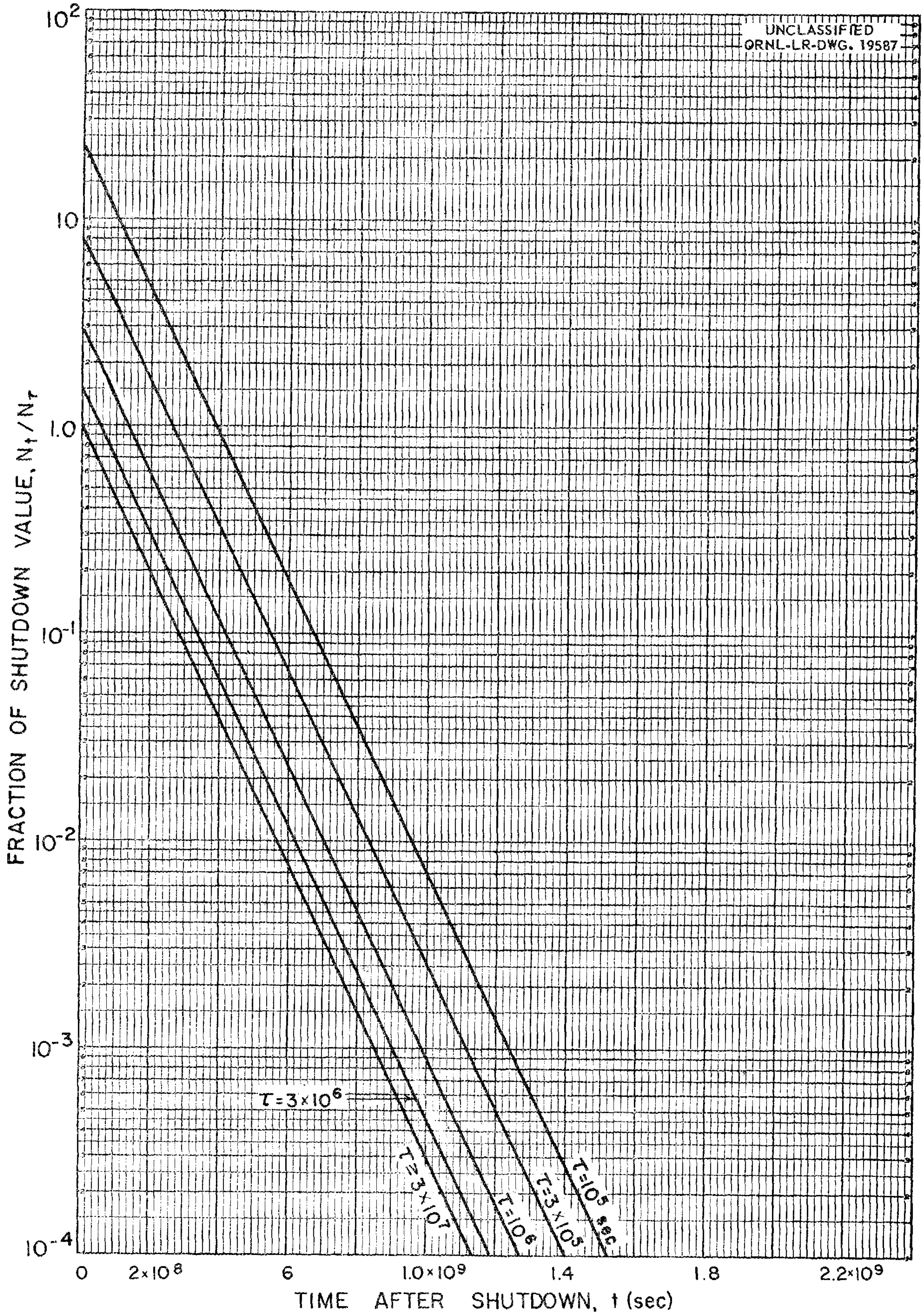

Fig. C-54a. Fraction of Shutdown Value of 2.7y Sb^{125} Remaining at Various Times After Shutdown.

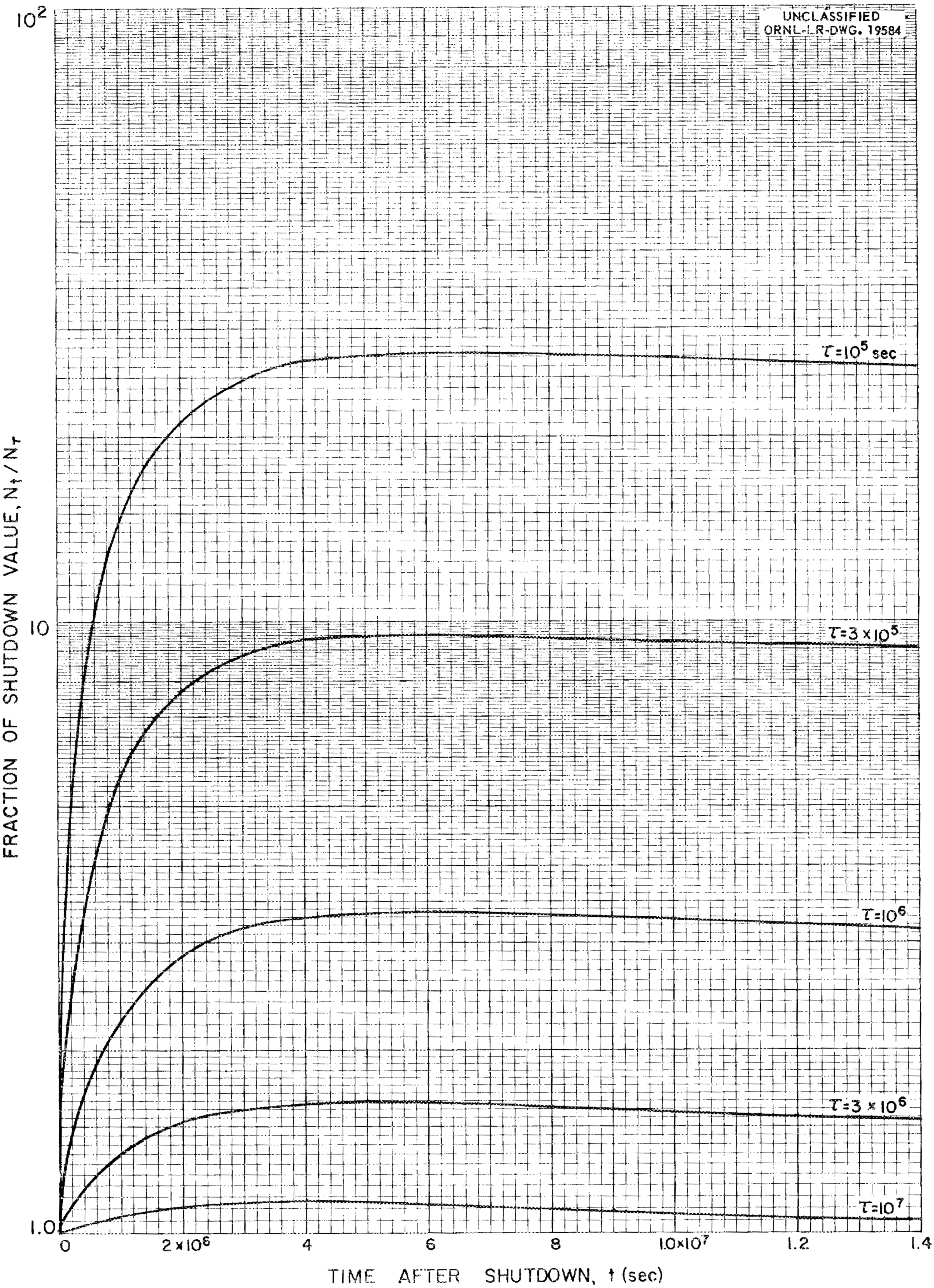

Fig. C-55. Fraction of Shutdown Value of 2.6y Pm^{147} at Various Times After Shutdown.

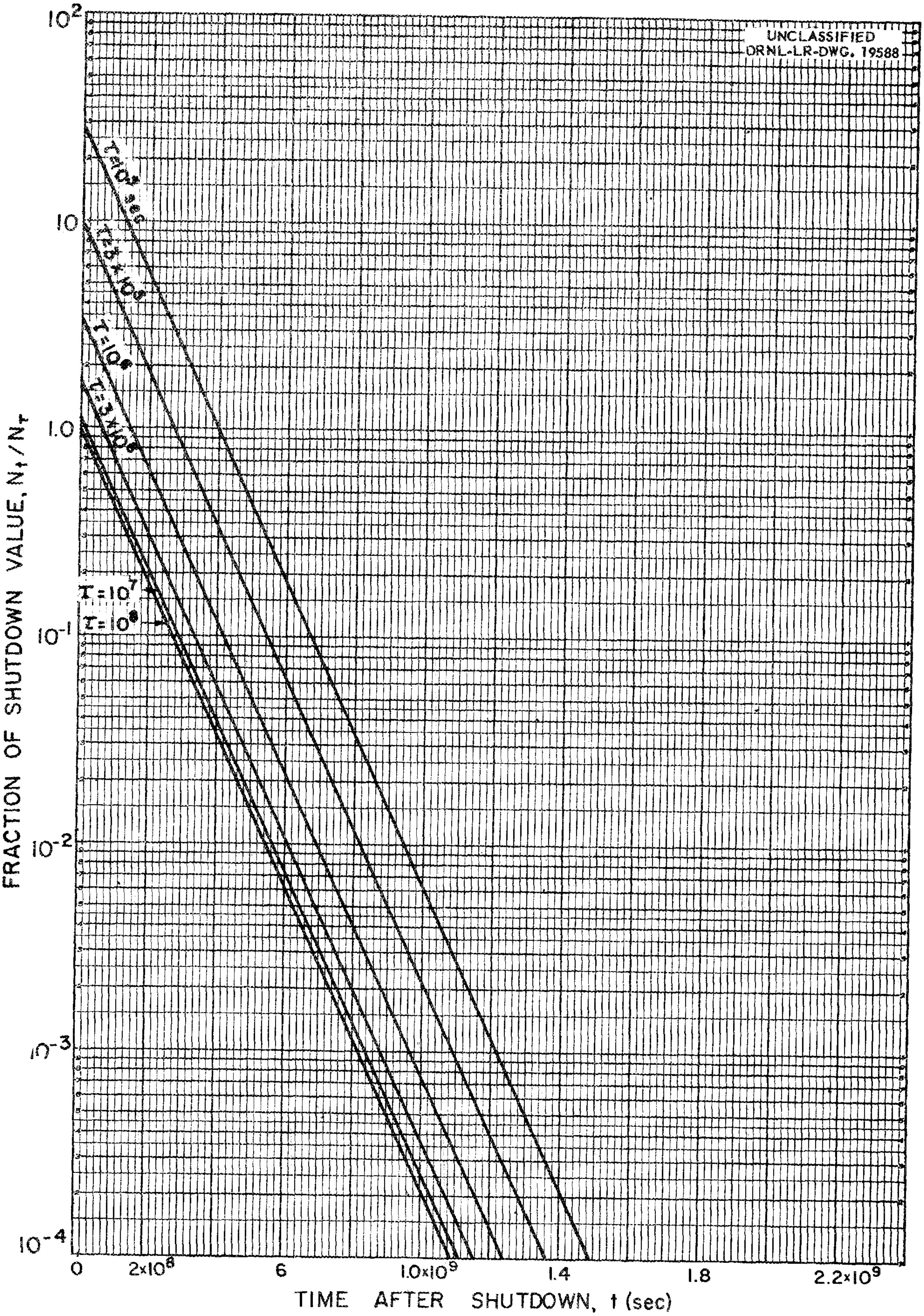

Fig. C-55a. Fraction of Shutdown Value of 2.6y Pm^{147} Remaining at Various Times After Shutdown.

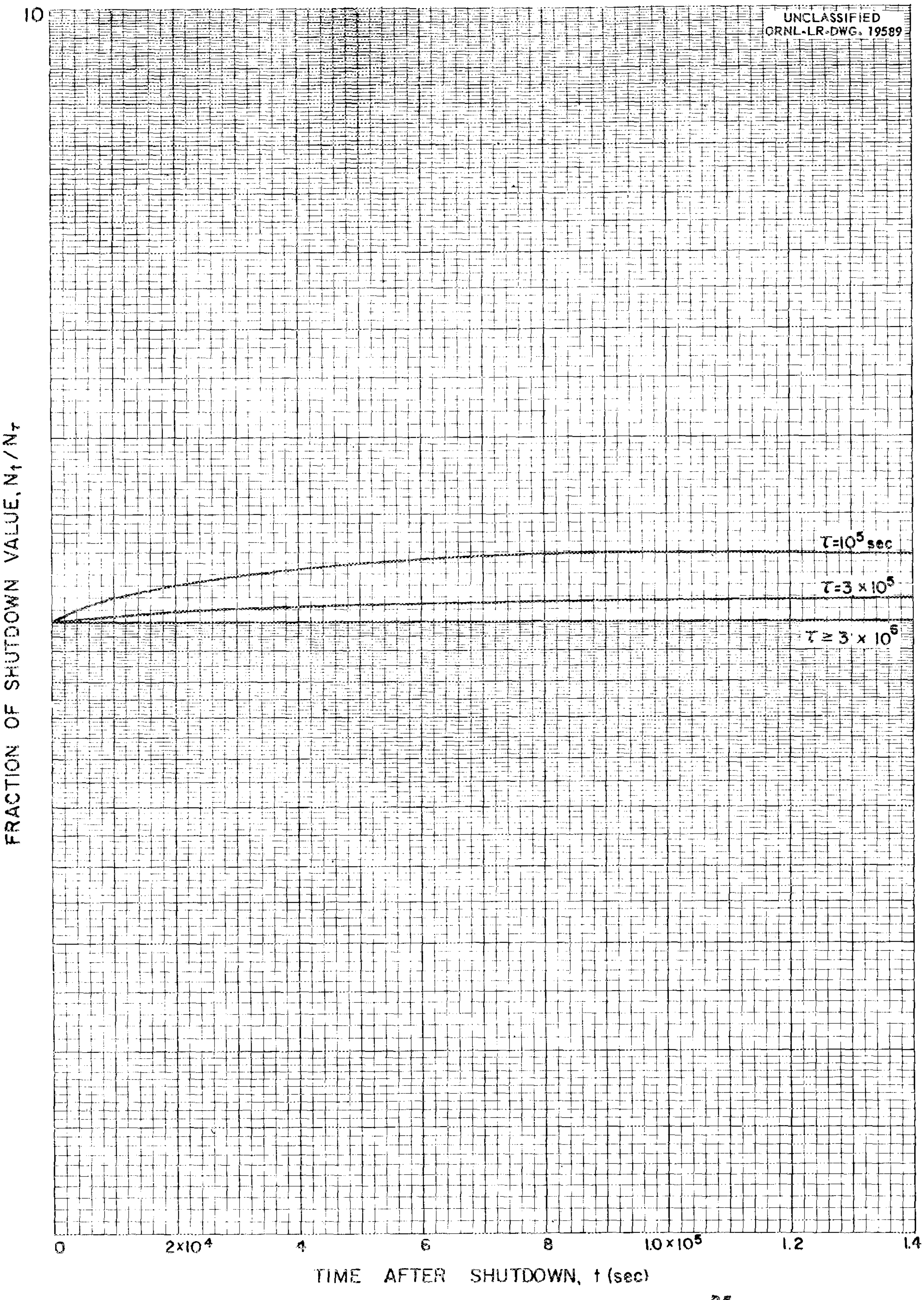

Fig. C–56. Fraction of Shutdown Value of 10.27y Kr^{85} at Various Times After Shutdown.

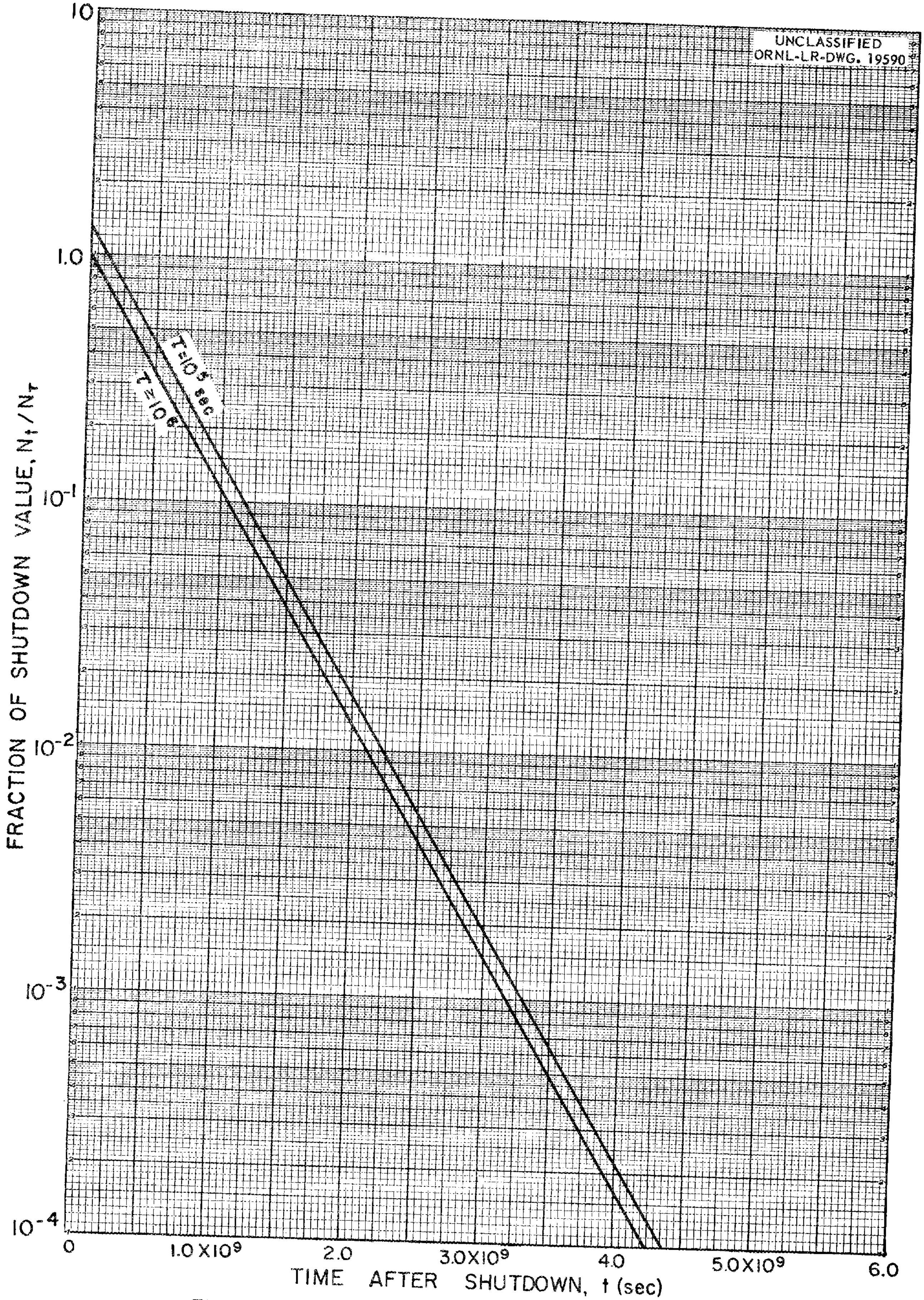

Fig. C-56a. Fraction of Shutdown Value of 10.27y Kr^{85} Remaining at Various Times After Shutdown.

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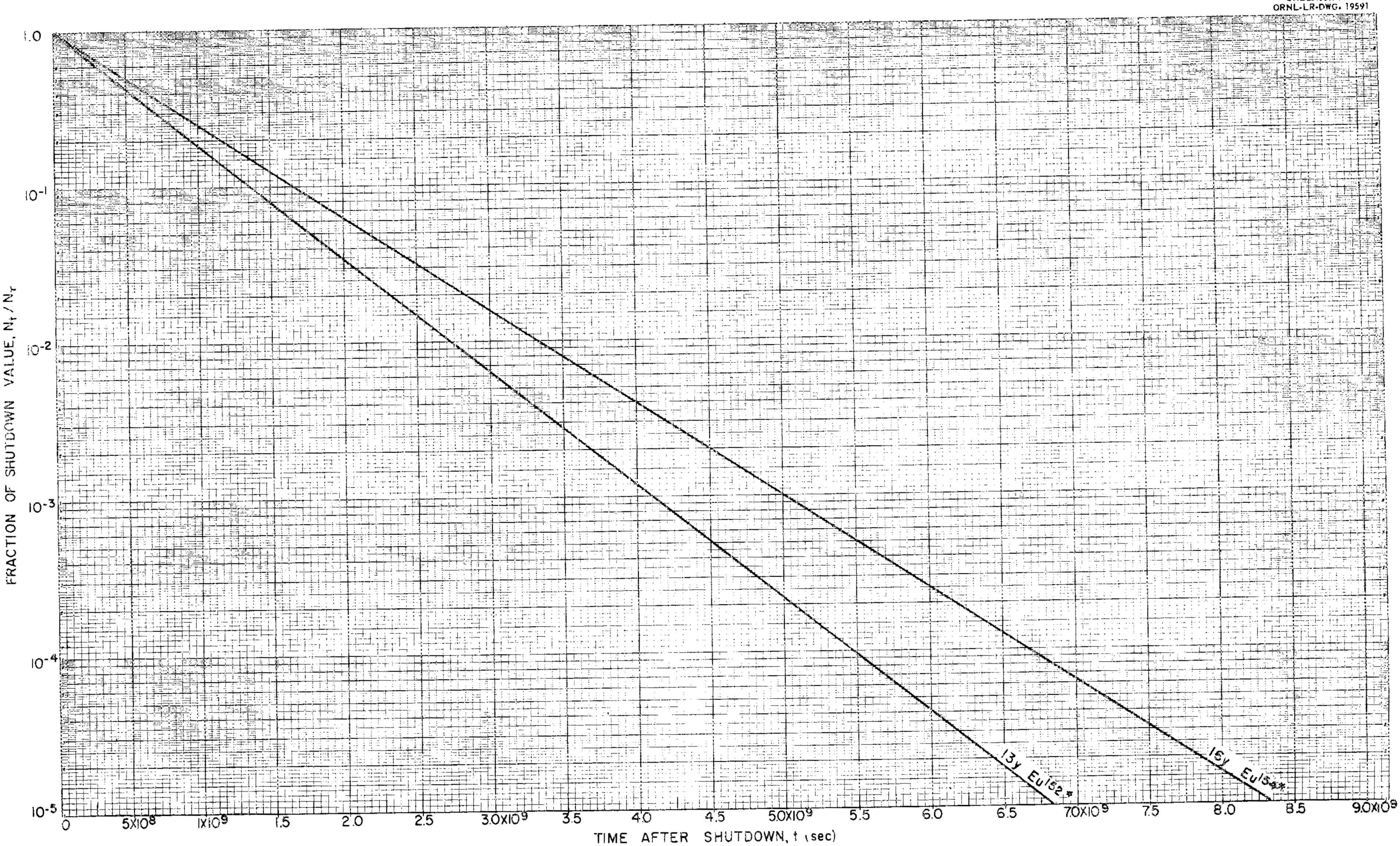

Fig. C-57. Fraction of Shutdown Value of Radioactive Fission Prouucts Remaining at Various Times After Shutdown.

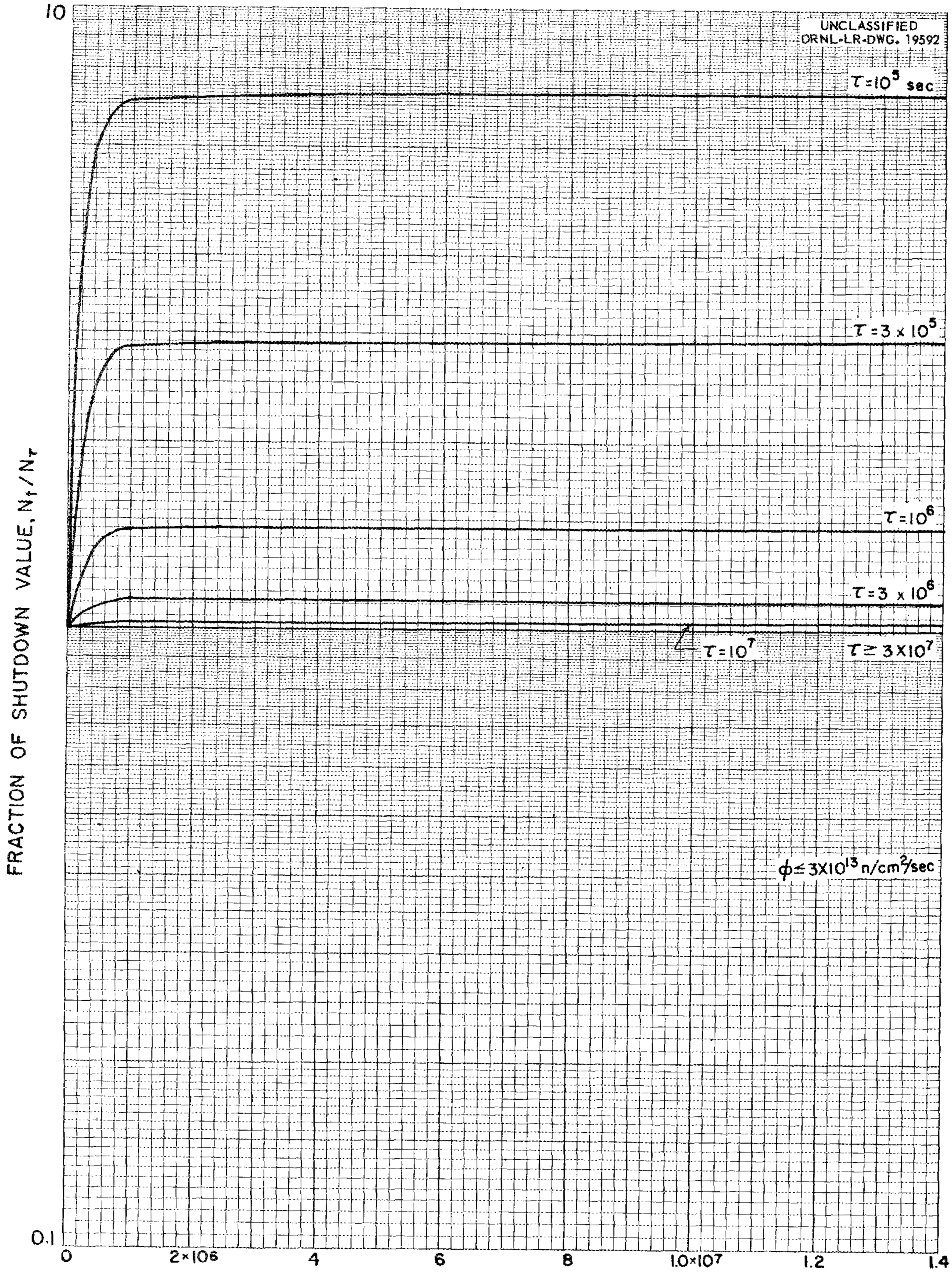

Fig. C-58. Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

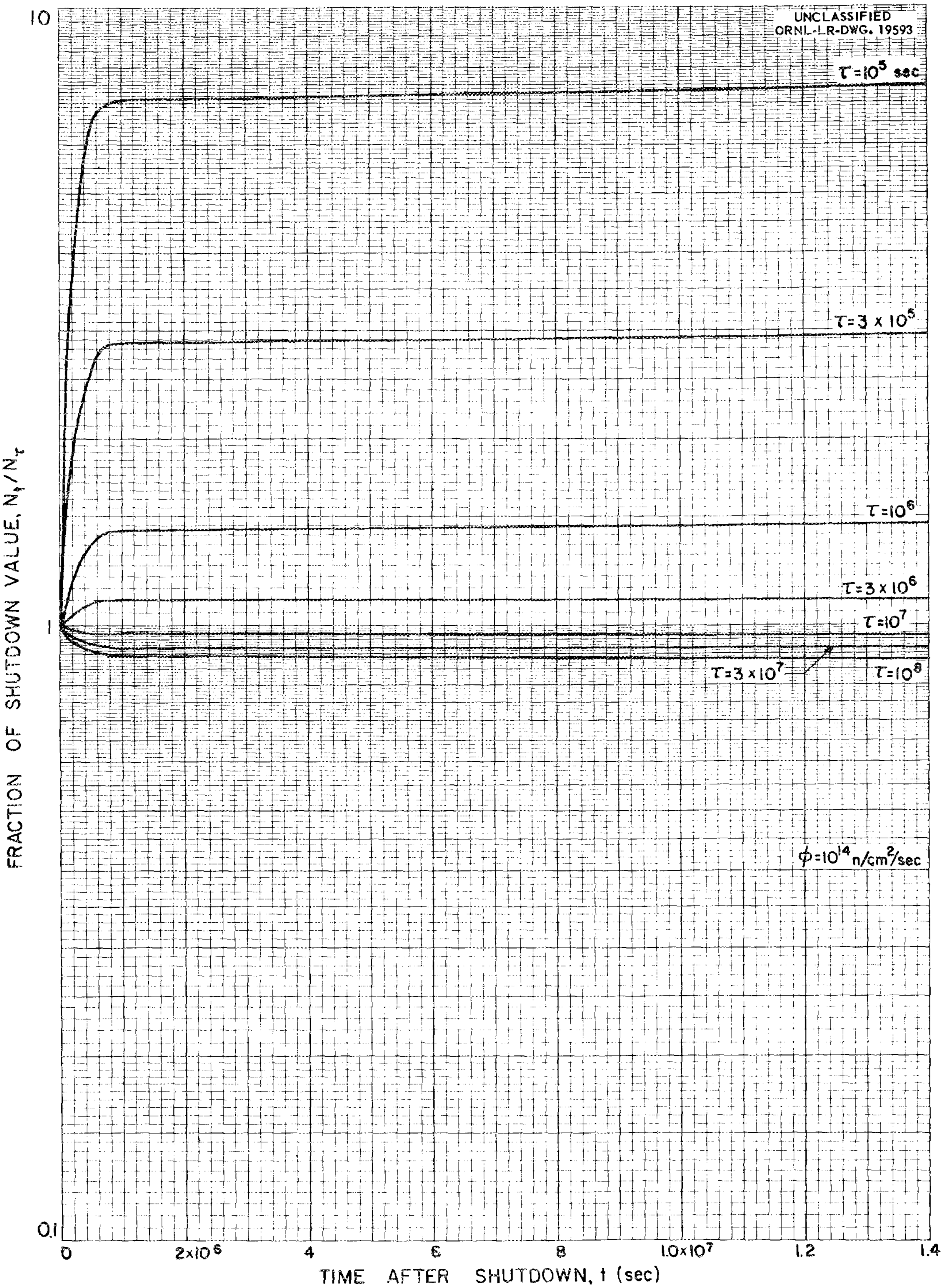

Fig.C-58a. Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

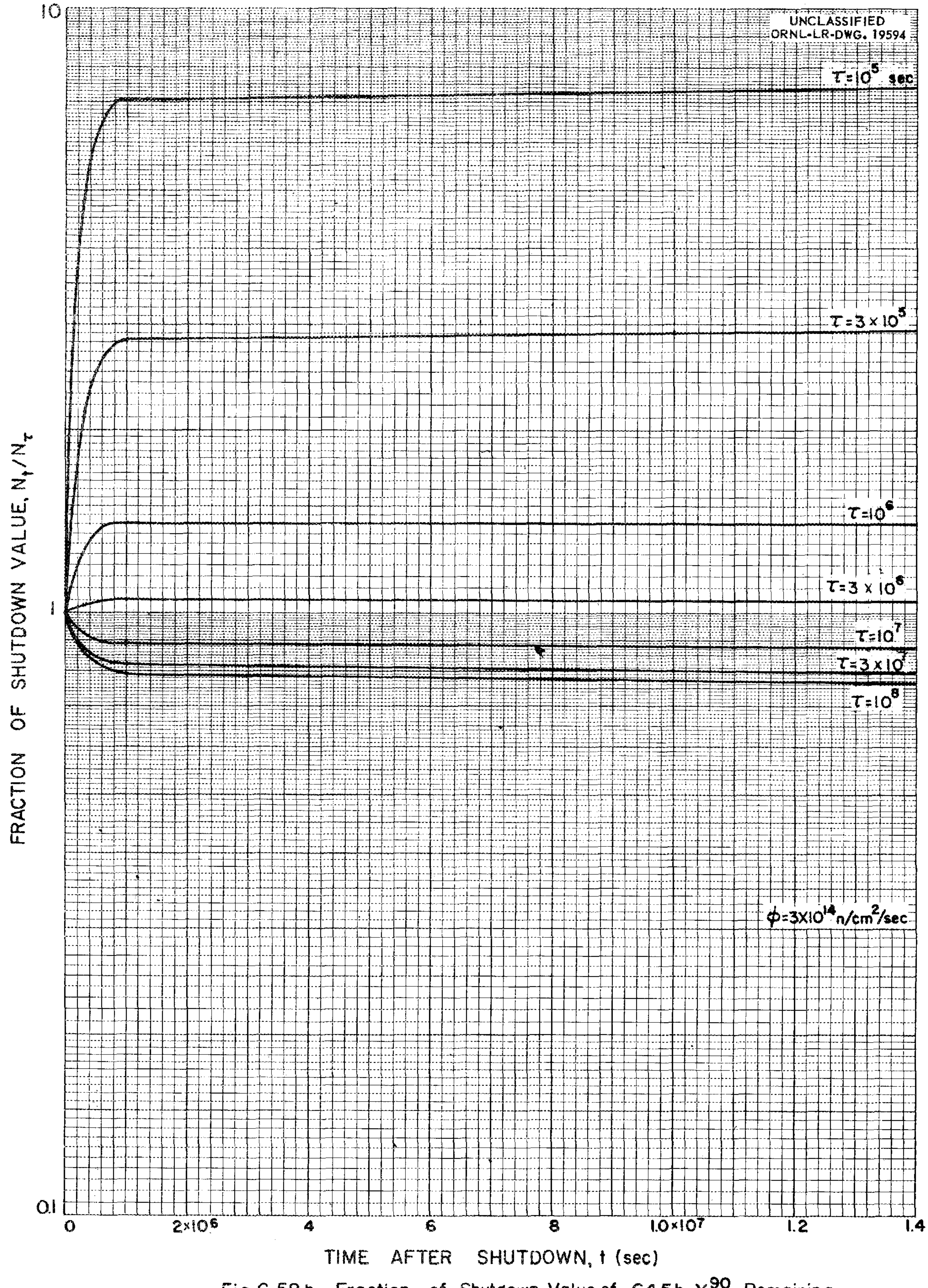

Fig. C-58 b. Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

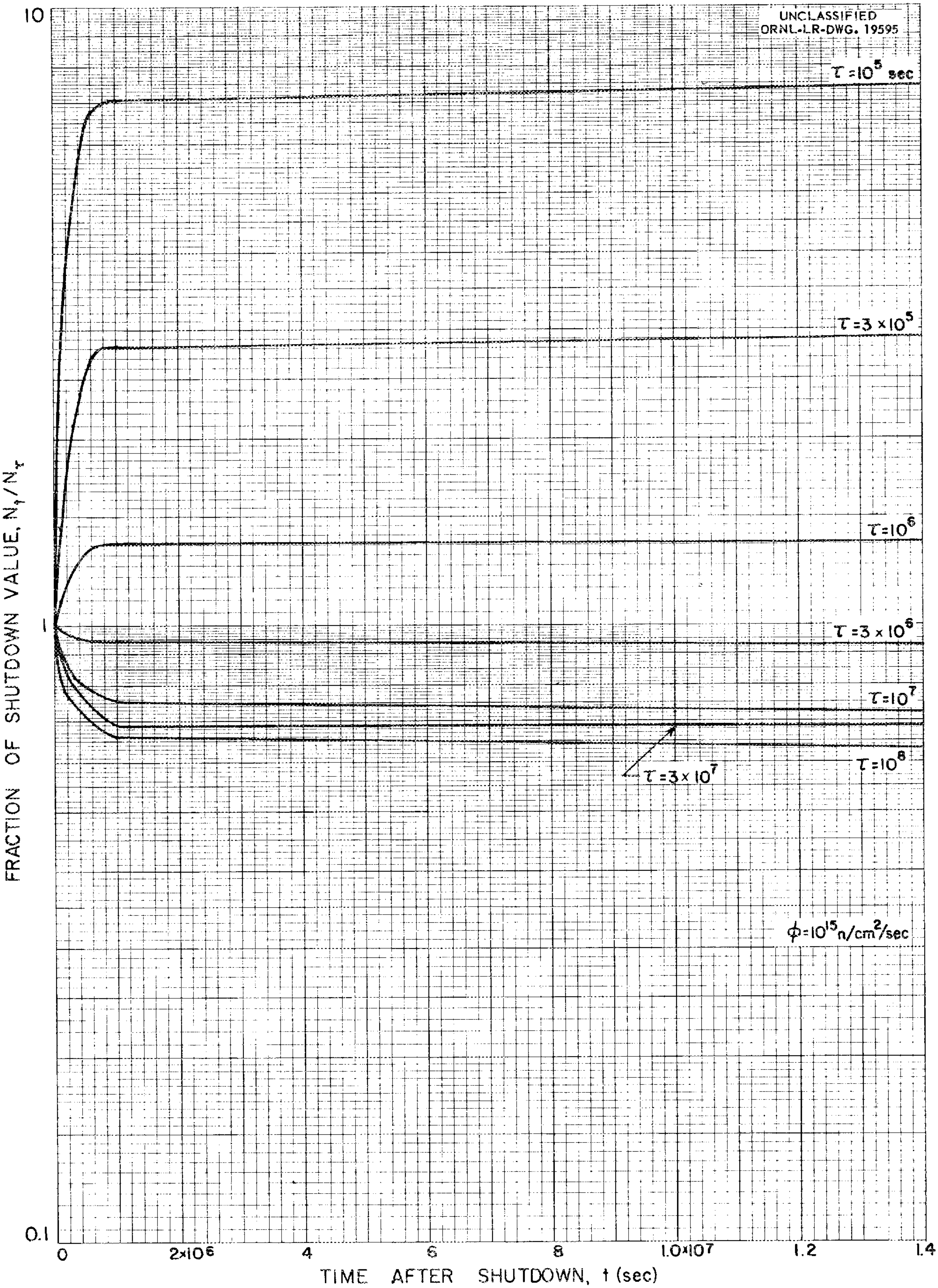

Fig. C-58c. Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

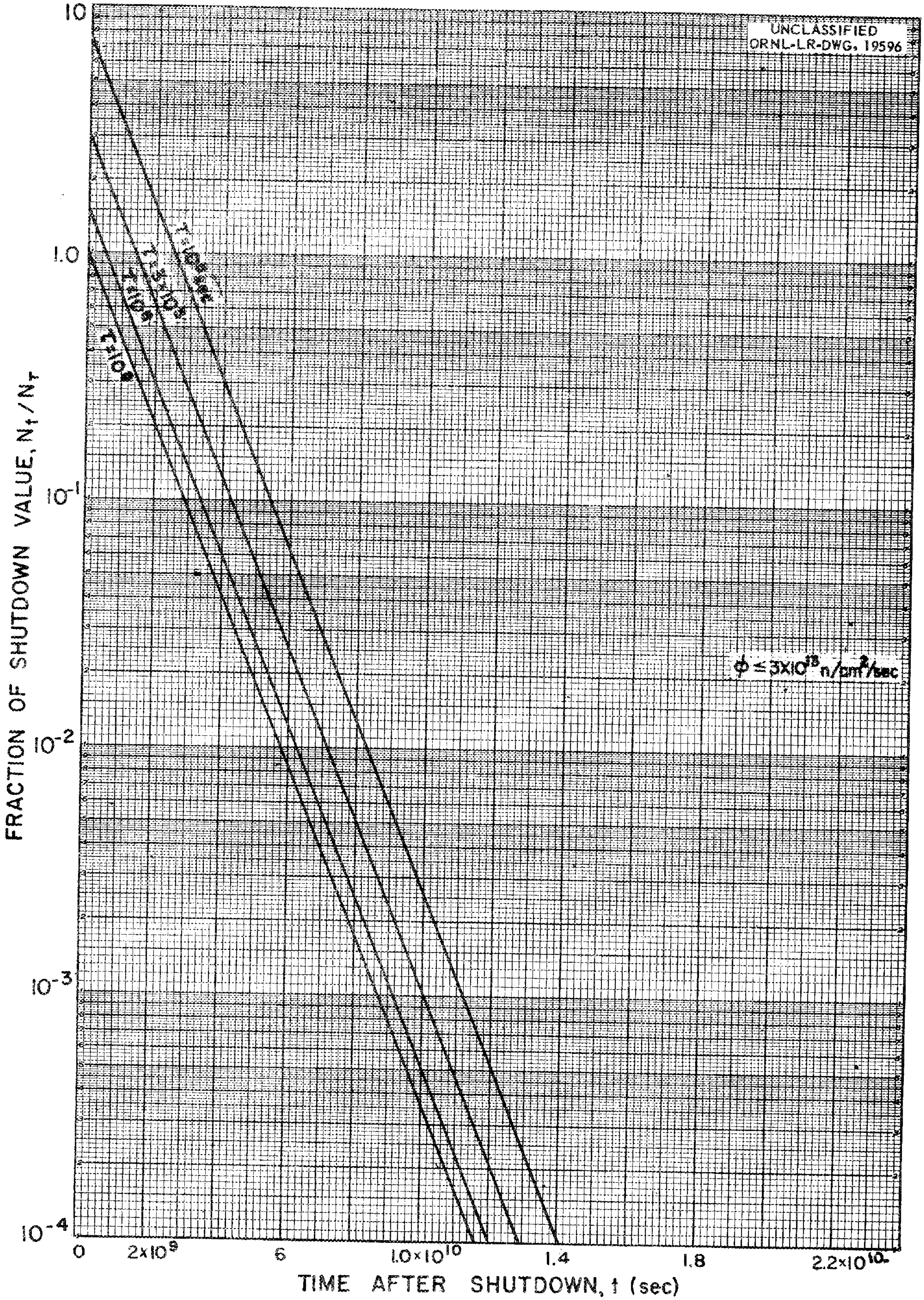

Fig. C-58d. Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

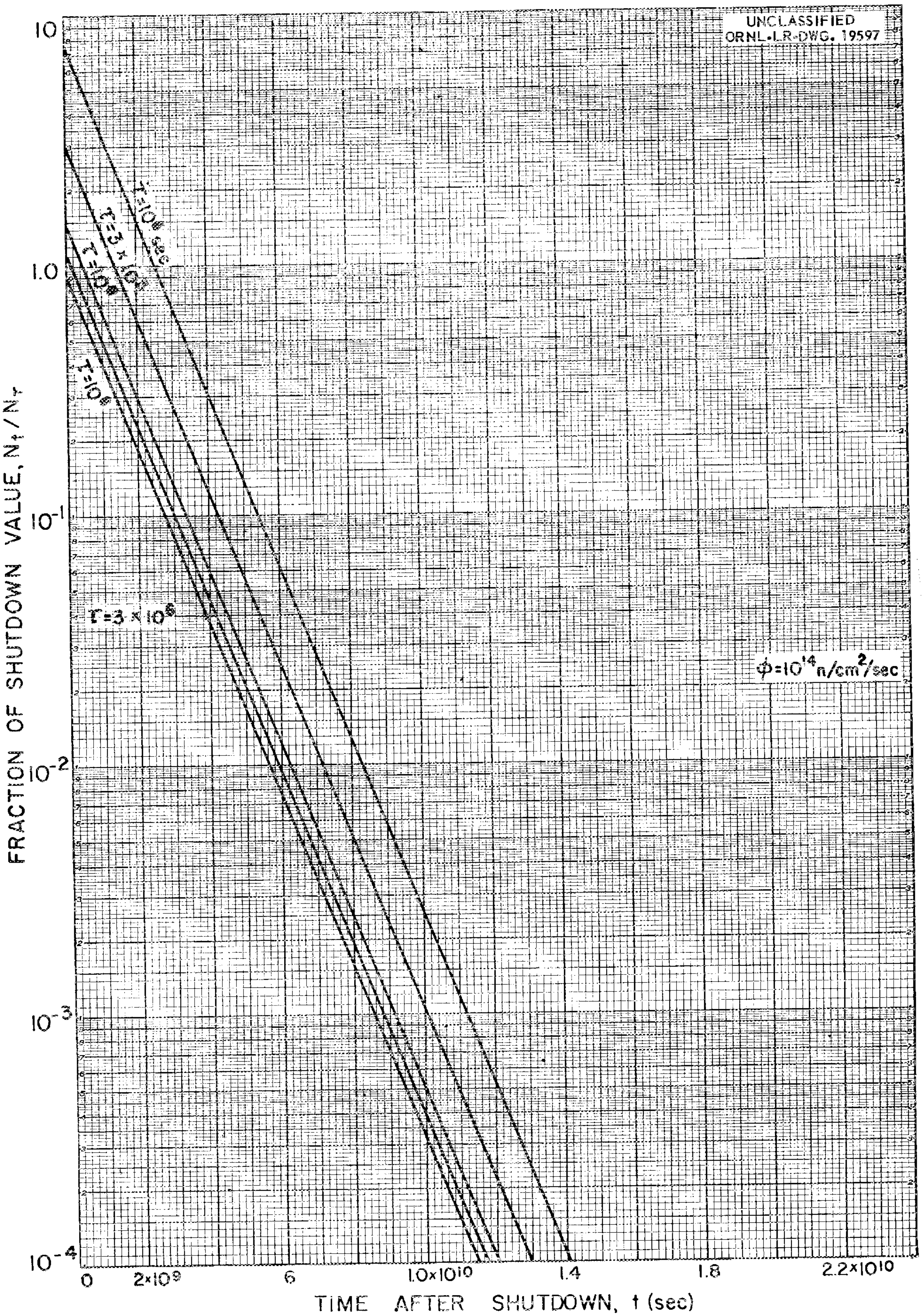

Fig. C-58e. Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

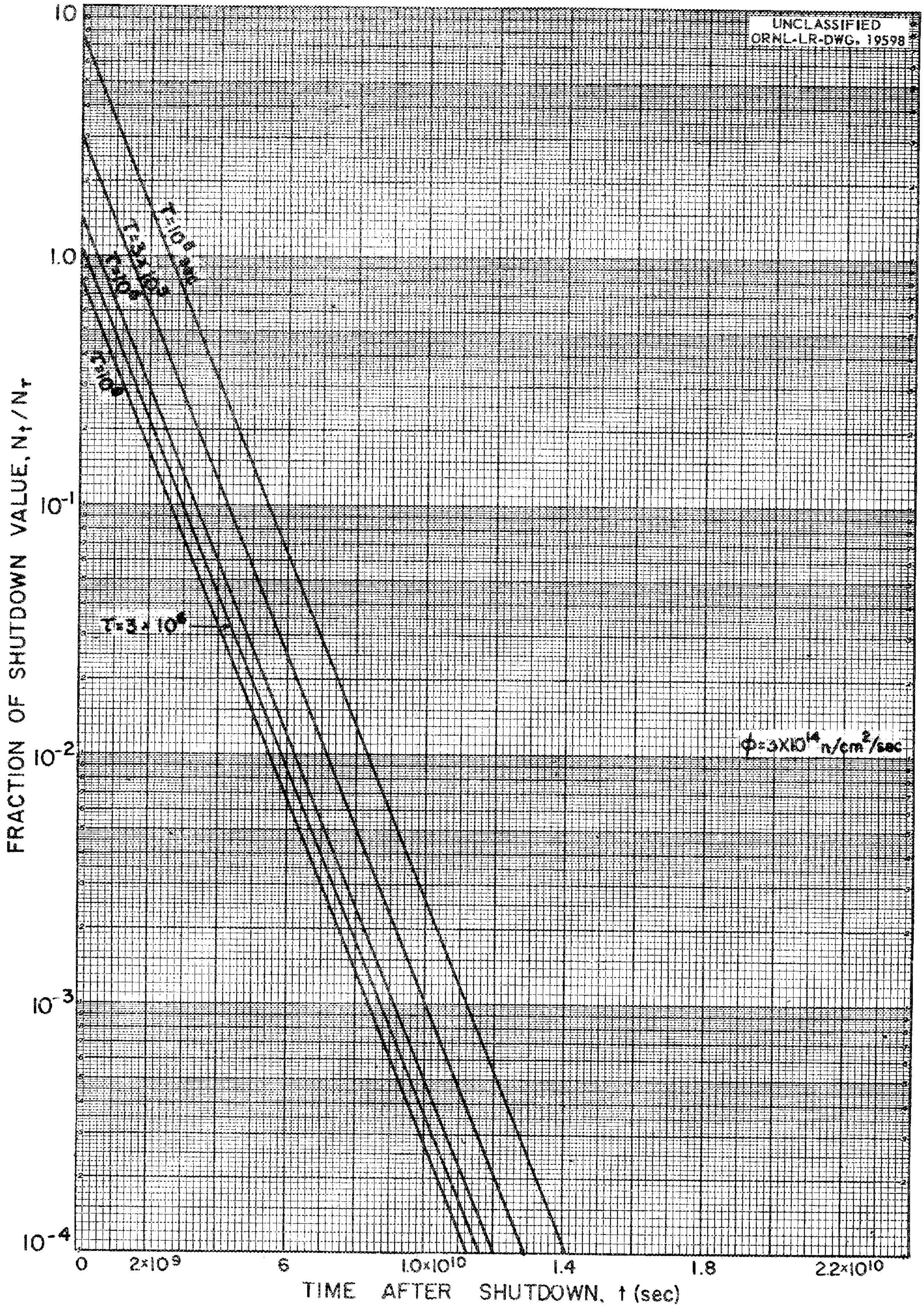

Fig. C-58f. Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

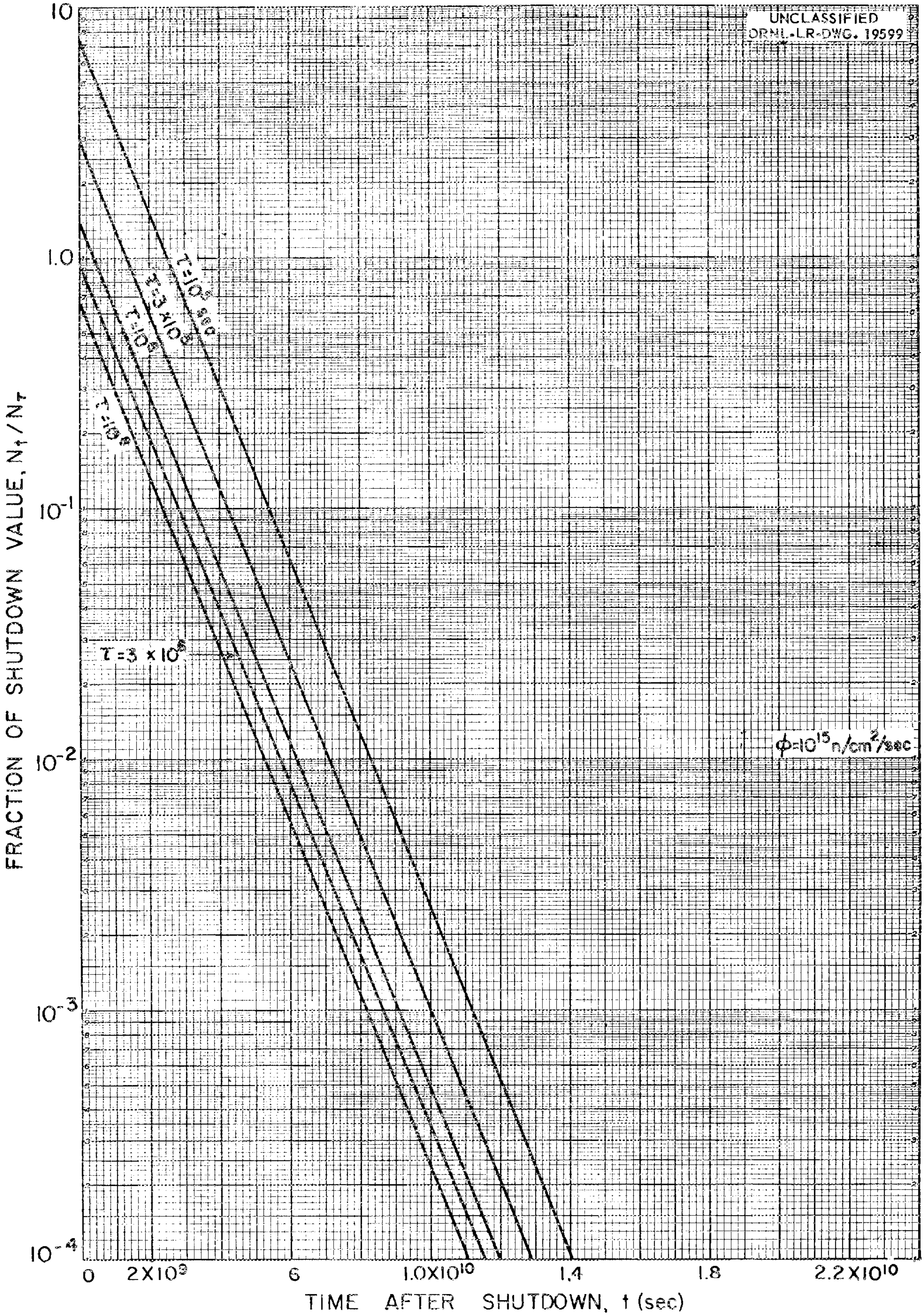

Fig. C-58g Fraction of Shutdown Value of 64.5h Y^{90} Remaining at Various Times After Shutdown.

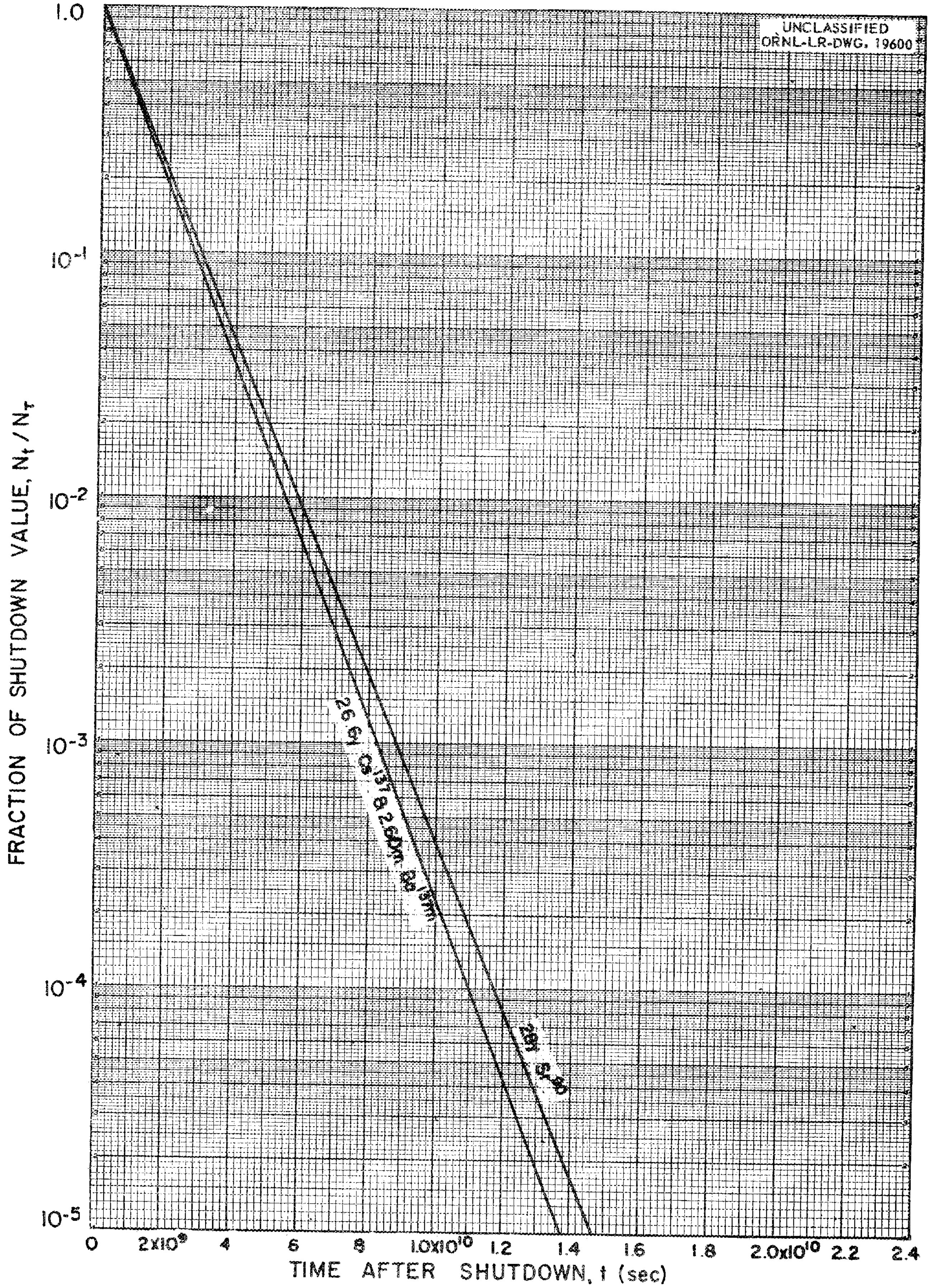

Fig. C-59. Fraction of Shutdown Value of Radioactive Fission Products Remaining at Various Times After Shutdown.

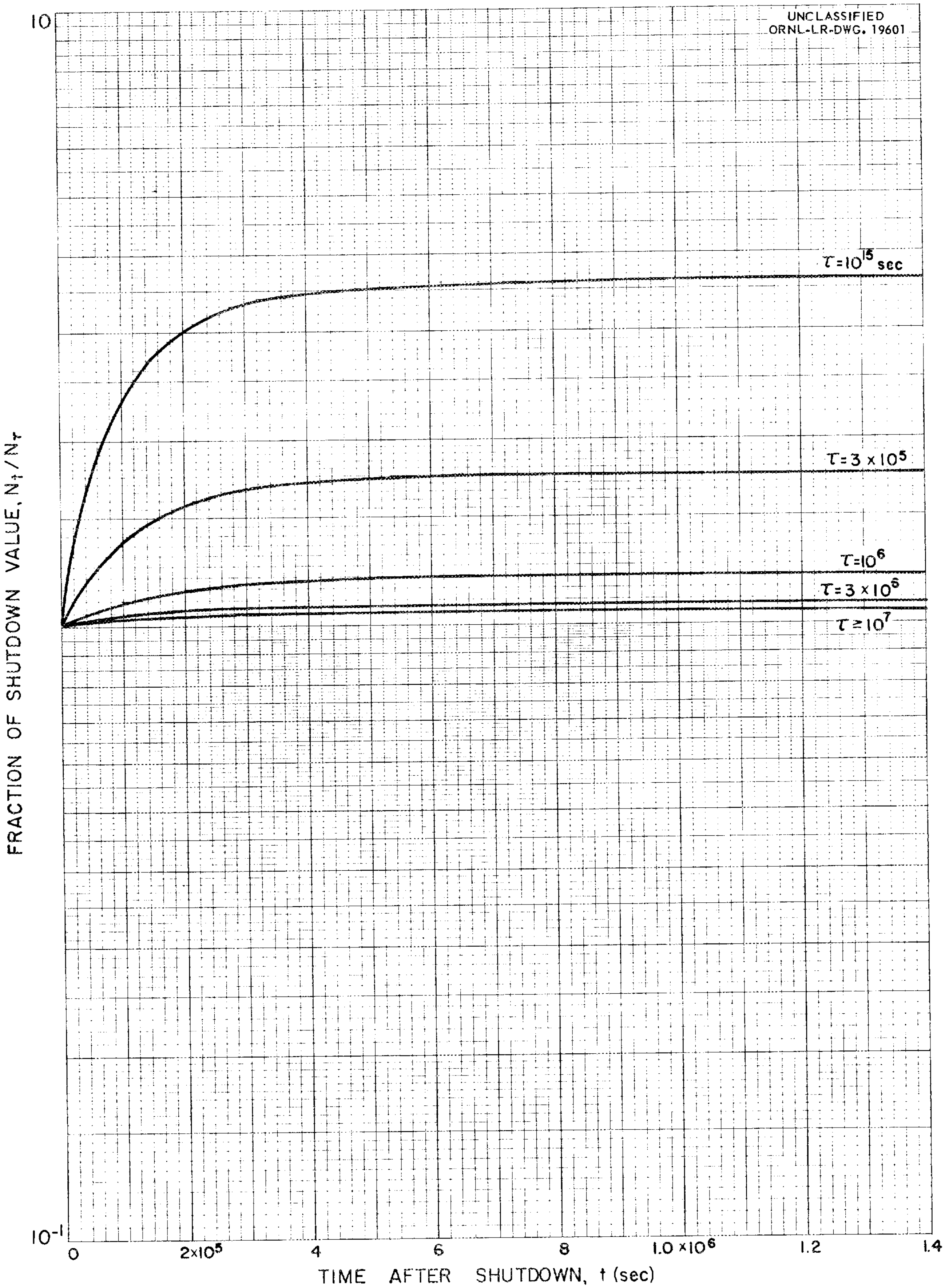

Fig. C-60. Fraction of Shutdown Value of 93y Sm^{151} Remaining at Various Times After Shutdown.

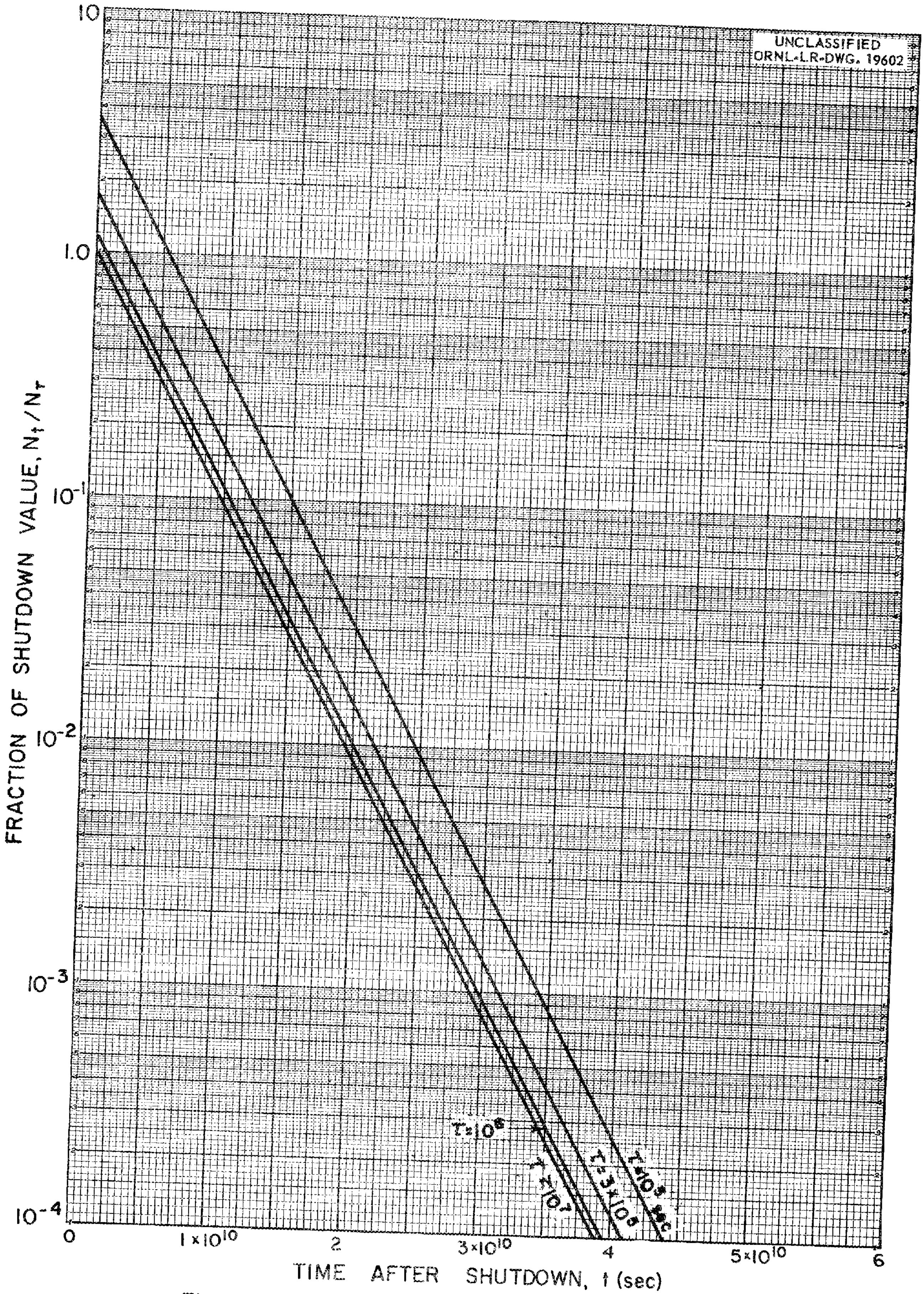

Fig. C-60a. Fraction of Shutdown Value of 93y Sm^{151} Remaining at Various Times After Shutdown.