OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

ORNL - TM - 595

COPY NO. - 20

DATE - 6/21/63

SHIELDING CALCULATIONS--POT CALCINATION DEMONSTRATION AT HANFORD

J. M. Holmes H. Pfohl E. D. Arnold

ABSTRACT

The results of shielding calculations are presented for the Pot Calcination Demonstration at Hanford. Stored pots containing Consolidated Edison waste cooled 180 days produced the highest dose rate of 18 mrem/hr through a 64-in. concrete shield. Purex waste (180-day cooled) in 8-in.-diameter pots gave 4.2 mrem/hr through the same shield. Purex waste source activities and fission product heating data are also presented.

1.0 INTRODUCTION

A radioactive demonstration of the pot calcination process is currently under design for installation in the new Fuels Recycle Pilot Plant at the Hanford Laboratories Operation, Richland, Washington. During this demonstration, a number of 6- to 12-in.-diam calcination pots filled with calcined solid wastes will be stored for observation prior to permanent disposal. Calculations have been made to determine if the shielding planned for the Fuels Recycle Pilot Plant cells will be adequate for storage of pots having 6- to 12-in. diam, containing wastes of varying composition and cooling time. The layout of pots under observation in the cells was arbitrarily assumed since the design of the actual storage location has not yet been completed. Two cells are currently under consideration for the pot storage, the mechanical cell which has a 12-ft x 19.5-ft floor area and four feet of high density (200 lb/ft^3) concrete shielding and the low bay cell which has a 22-ft x 25-ft floor area and 5-ft 4-in. shielding walls of normal density concrete. The calculations were performed for both cases.

Source activities for the shielding calculations were determined using the PHOEBE code, and the shielding calculations were performed using the SDC (Shielding Design Calculation) code developed by E. D. Arnold and B. F. Maskewitz for the IBM 7090 computer.[1]

2.0 LAYOUT OF CALCINATION POTS

Figure 1 shows the layout of the calcination pots assumed for the two cells. Two rows containing 28 pots placed on 18-in. centers were proposed for the low bay cell with the centerline of the closest row 3 ft away from the wall. In the mechanical cell, 39 calcination pots were placed on 18-in. centers in three rows with 2 ft between the rows.

---

[1] E. D. Arnold and B. F. Maskewitz, SDC - A Shielding Design Calculation Code for Fuel Handling Facilities, ORNL-3041 (to be published).

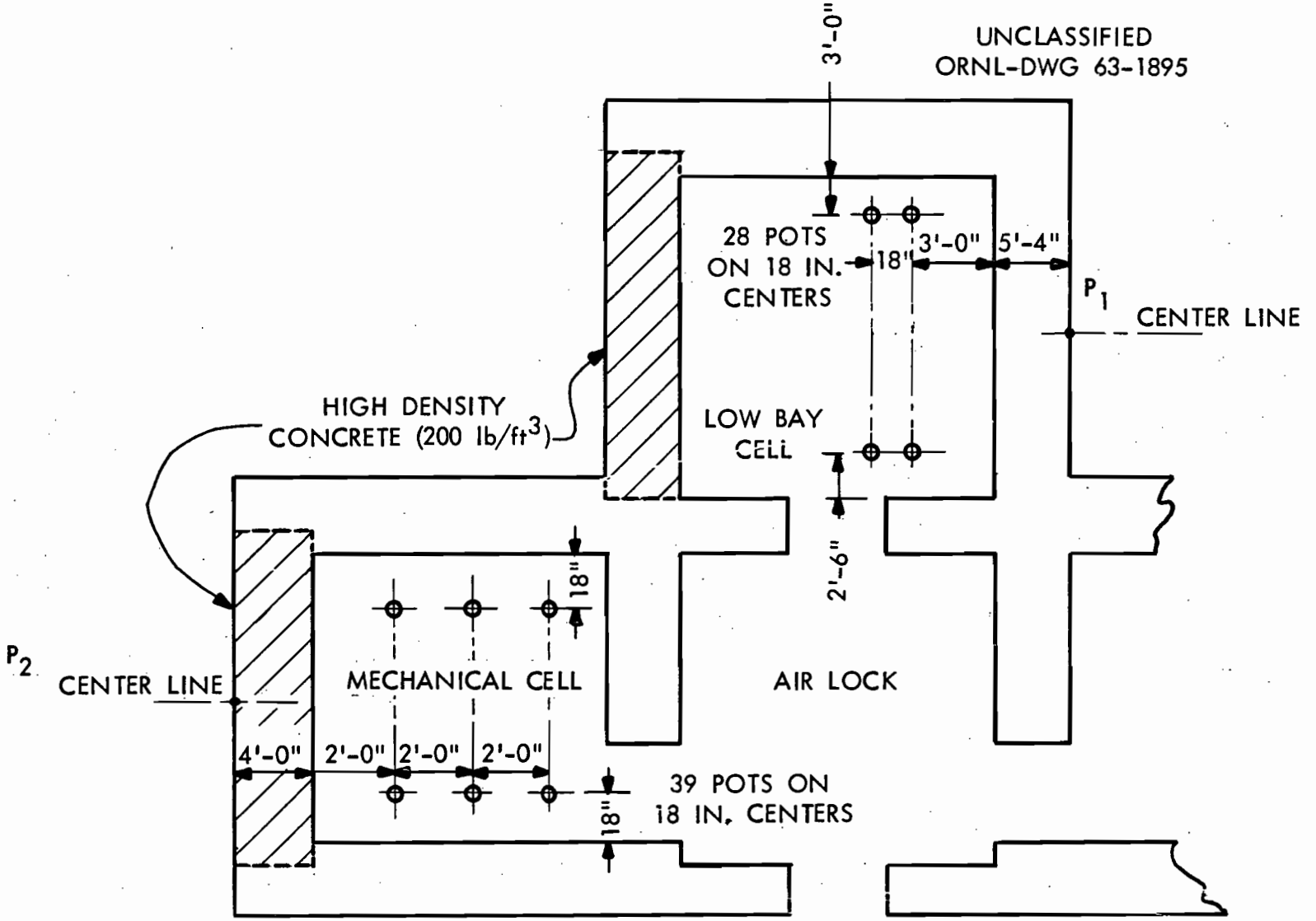

Fig. 1. Layout of Calcination Pots for Shielding Calculations-Waste Calcination Demonstration Program.

More space was left between the low bay cell wall and the first row of pots in order to allow room for unit shielding if needed. The computer calculations determined the dose rate from each pot using the distance between the pot centerline and a point at the wall along the centerline of the pot rows. This point is labeled P_1 for the low bay cell and P_2 for the mechanical cell. The shielding provided by the calcination pot rows positioned nearer the wall was not taken into consideration in this program.

3.0 WASTE CHARACTERISTICS

Shielding calculations were made for wastes from Consolidated Edison and APPR-1 fuels processed by the Darex process, TBP-25 waste from the Idaho Chemical Processing Plant, and Purex waste produced at Hanford (Table 1). Activity levels were determined by the PHOEBE code using burnup, power level and cooling time except for the TBP-25 waste where radiochemical analyses of ICPP tank WM-185 were used. Eight-in.-diam pots were selected for the Consolidated Edison and APPR-1 wastes, 6- and 8-in.-diam pots for Purex and 12-in.-diam pots for the TBP-25 wastes. These pot sizes were assumed based upon internal heat dissipation considerations. Cooling times varying between 60 and 730 days were used for the calculations, except for the TBP-25 case where the activities in tank WM-185 during February 1960 and February 1962 were used.

4.0 SHIELDING EFFECTIVENESS

The high density concrete in the mechanical cell was more effective than the normal density concrete in the low bay cell, even though more pots were stored in the mechanical cell. Figures 2, 3, 4, and 5 present the gamma dose rate-cooling time curves for Purex (6- and 8-in.-diam pots), APPR-1 Darex and Consolidated Edison Darex, respectively. The dose rates for TBP-25 waste were less than 0.2 mrem/hr for the low bay cell and less than 0.1 mrem/hr for the mechanical cell at the highest activity level.

The highest activity levels expected will be created by the Consolidated Edison Darex waste. If cooled 180 days and stored in the low bay cell, the

Table 1. Waste Characteristics

Waste Type	Burnup	Power Level	Solid Waste		Pot Dimensions
			Volume	Density, g/cc	
Consolidated Edison Darex Process	23,100 Mwd/tonne Th	38.5 Mw/tonne Th	422 liters/tonne Th	1.40	20.3 cm diam x 183 cm long
APPR-1 Darex Process	42% burned	0.5 Mw/kg U^{235}	13.8 liters/kg U^{235}[a]	1.40	20.3 cm diam x 183 cm long
TBP-25	b	b	60.5 liters/kg U^{235}[a]	0.75	30.5 cm diam x 183 cm long
Purex	-	-	19.0 liters/tonne U	1.50	15.2 and 20.3 cm diam x 183 cm long

[a] After burnup.

[b] The activity was estimated from a radiochemical analysis of tank WM-185 at ICPP dated 2/18/60.

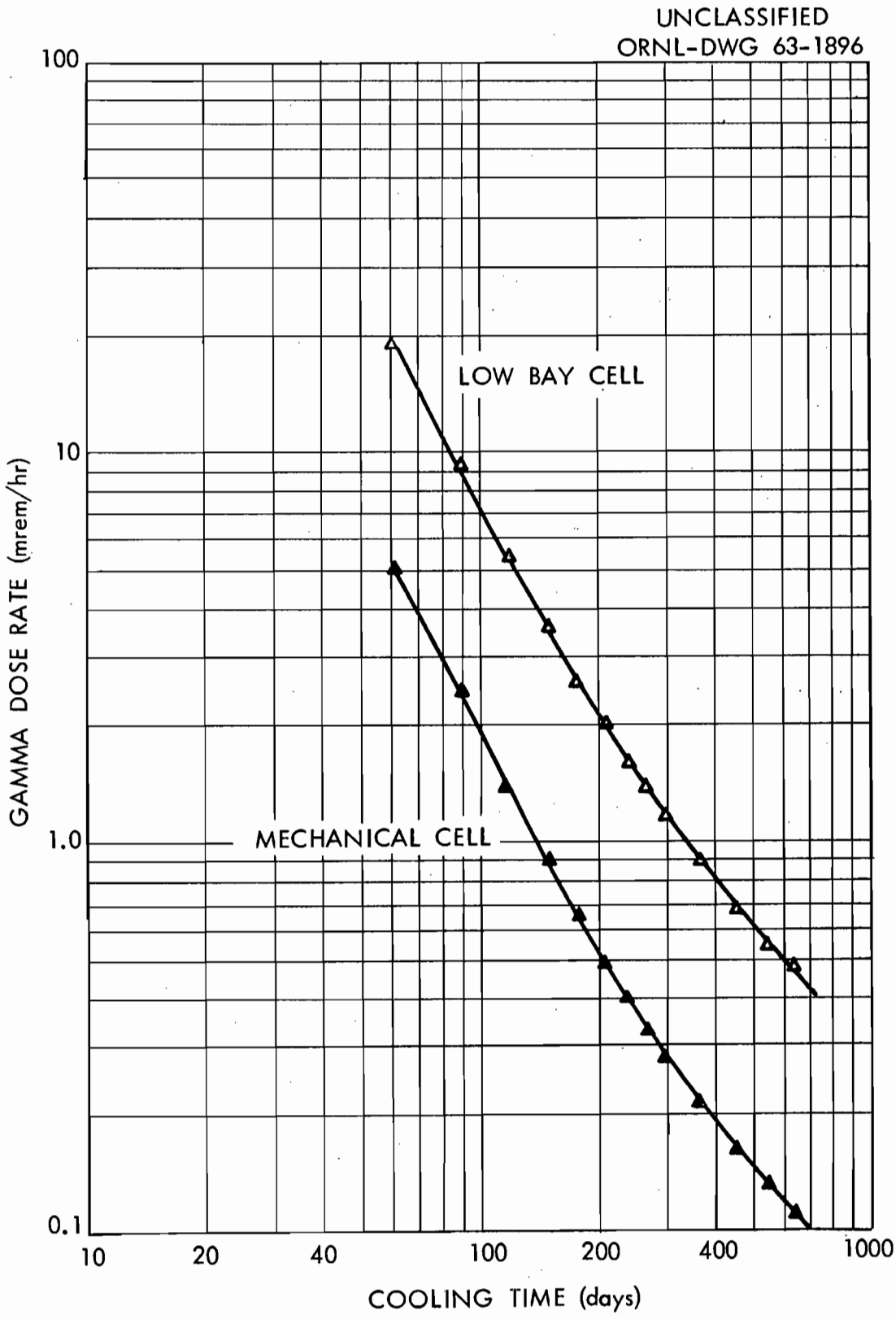

Fig. 2. Gamma Dose Rate from Purex (Pot Radius = 7.6 cm).

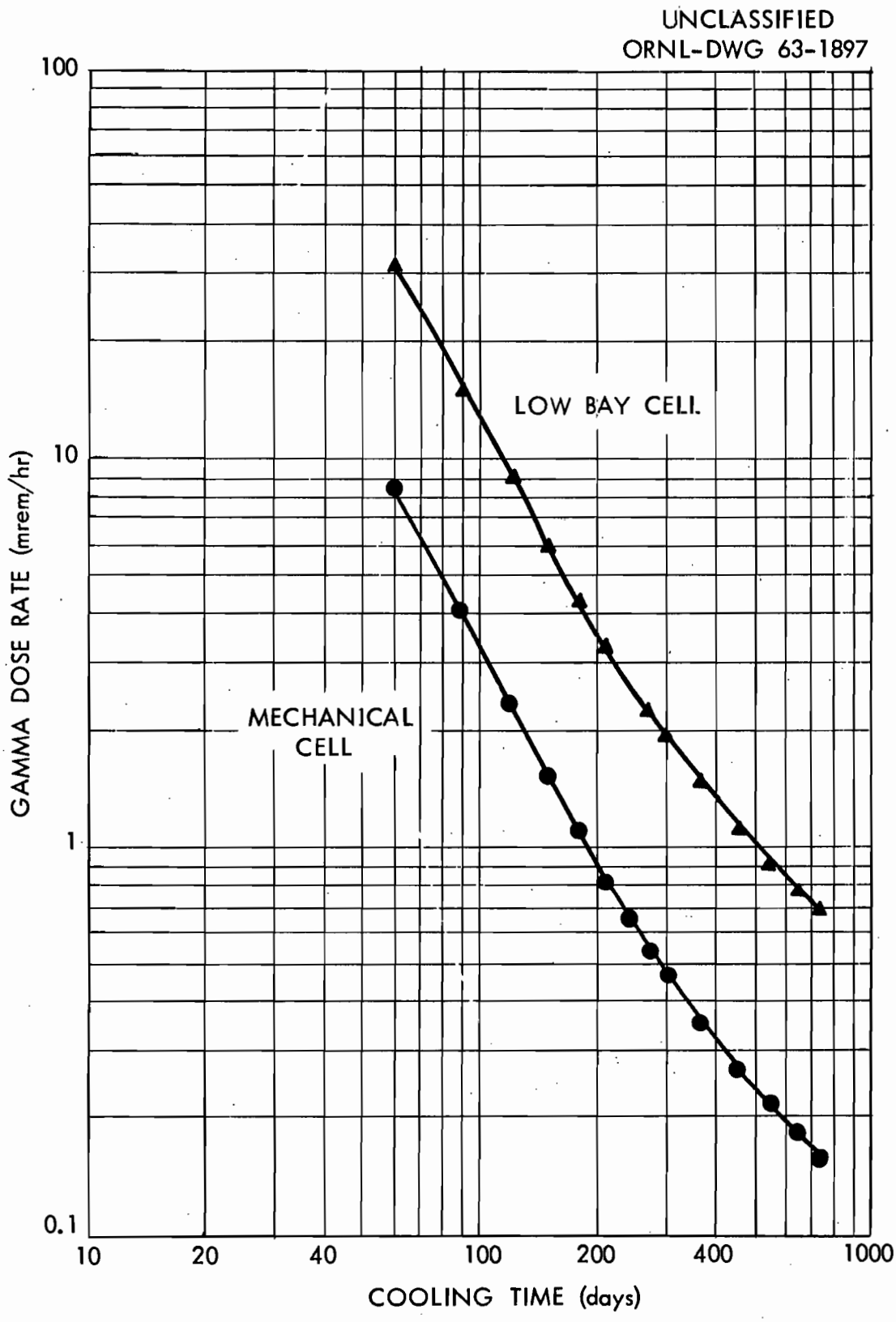

Fig. 3. Gamma Dose Rate from Purex (Pot Radius = 10.2 cm).

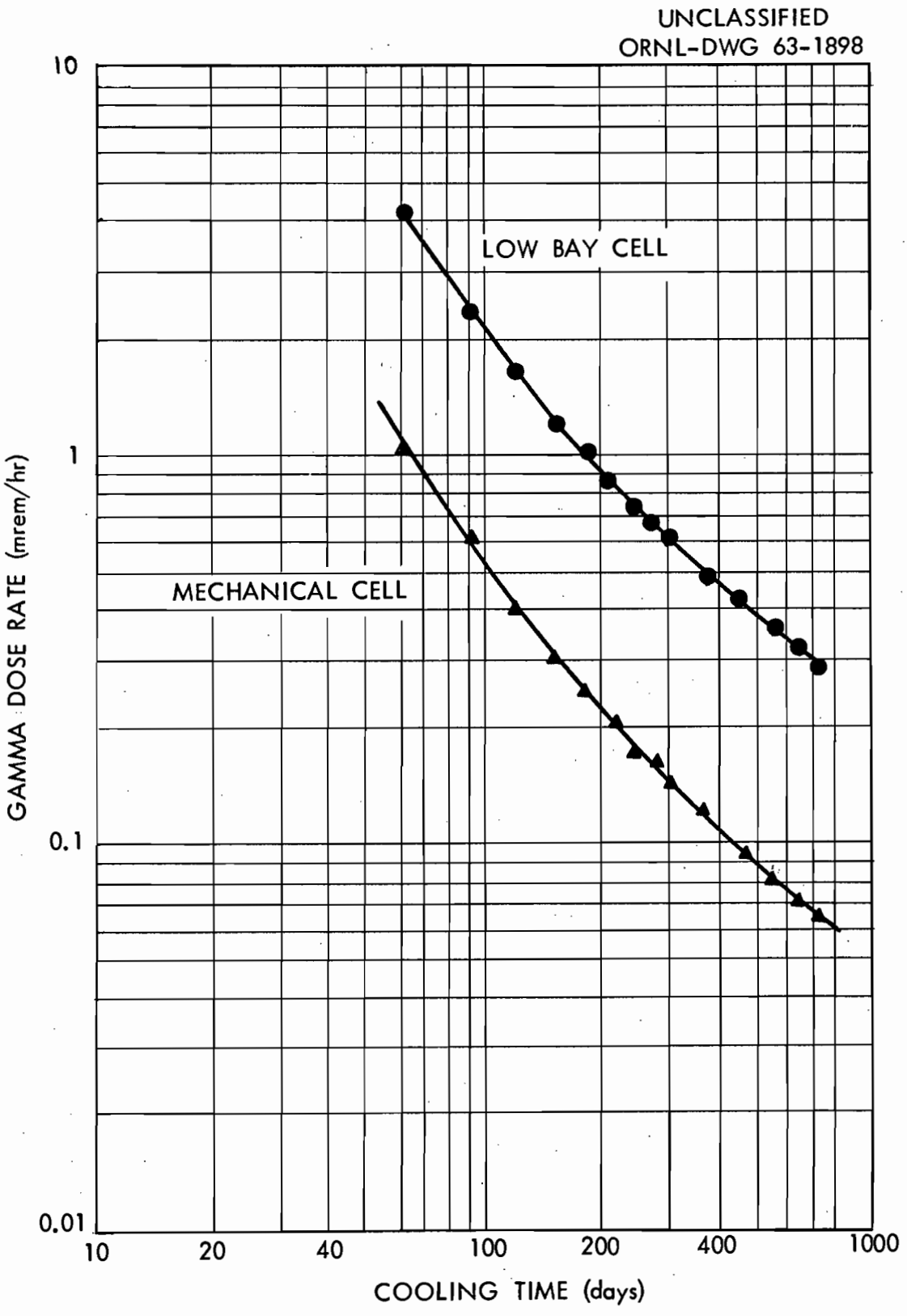

Fig. 4. Gamma Dose Rate from APPR Darex.

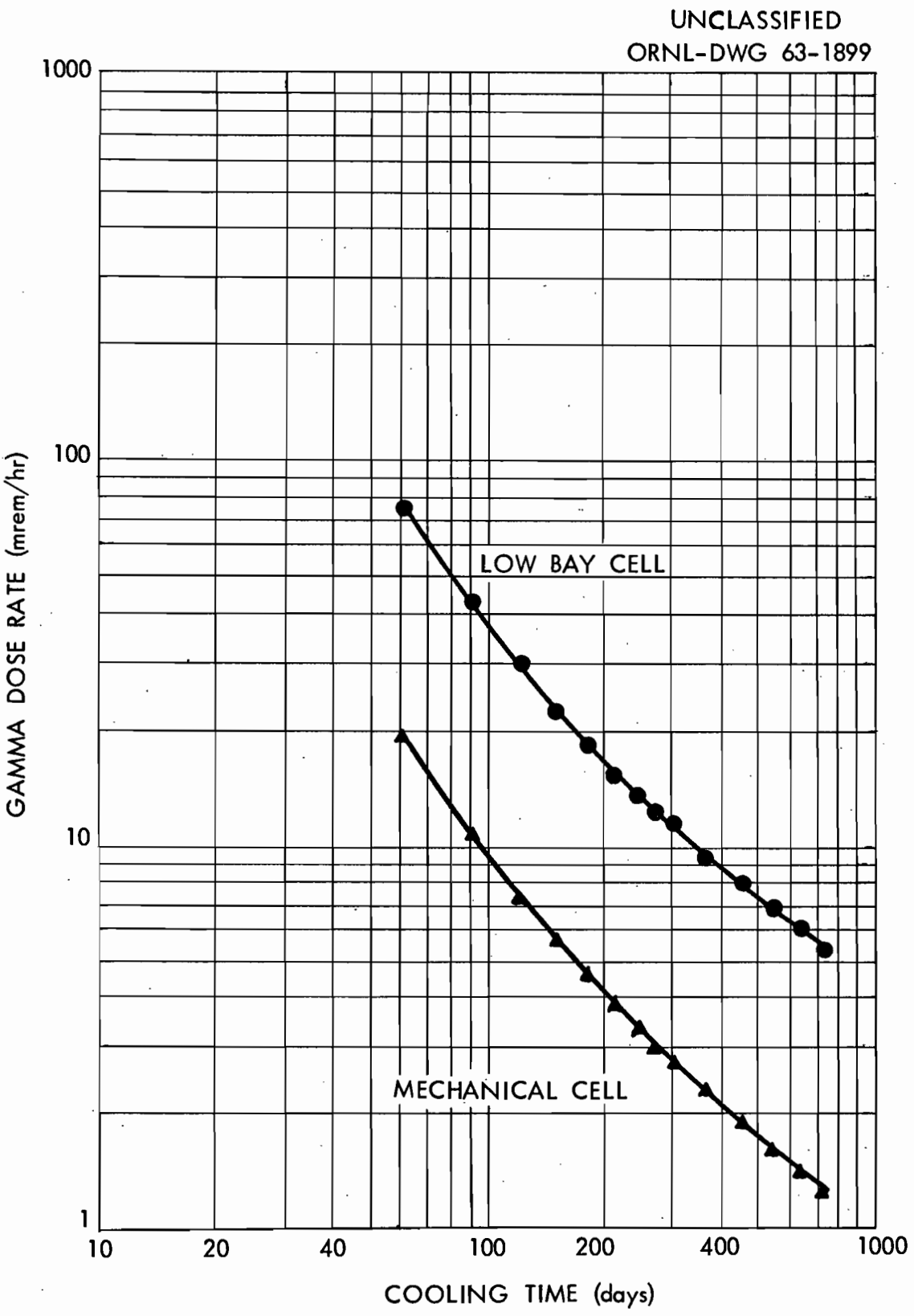

Fig. 5. Gamma Dose Rate from Con-Ed Darex.

28 pots will produce an 18 mrem/hr dose rate at the wall. Large diameter pots (8-in. diam) containing 180-day cooled Purex waste will give 4.2 mrem/hr while 6-in.-diam pots will reduce this to 2.6 mrem/hr (Fig. 6). Therefore, it appears that either of these cells will be adequate for storing all but the Consolidated Edison wastes, assuming a maximum allowable dose rate of 10 mr/hr at contact. Consolidated Edison Darex waste can also be stored in the low bay cell if cooled beyond 340 days or in the mechanical cell if cooled beyond 95 days.

A comparison of the shielding effectiveness of the high and low density concretes for the different waste types is made in Table 2. Pots with similar source to subject distances were chosen and their dose rates tabulated. In all cases the dose rates through the high density concrete are only 17 to 20% of that through the 33% thicker ordinary concrete in the low bay cell.

5.0 CALCINED PUREX WASTE ACTIVITY AND INTERNAL HEAT GENERATION RATES

The PHEOBE code tabulates the source strengths and fission product heating rates for each cooling time. These values were converted to beta and gamma activities in calcined Purex solids and internal heat generation rates expected per cubic foot of calcined Purex (Figs. 7, 8, and 9). The internal heat generation rates compared with those calculated from ORNL-2127 are slightly higher.

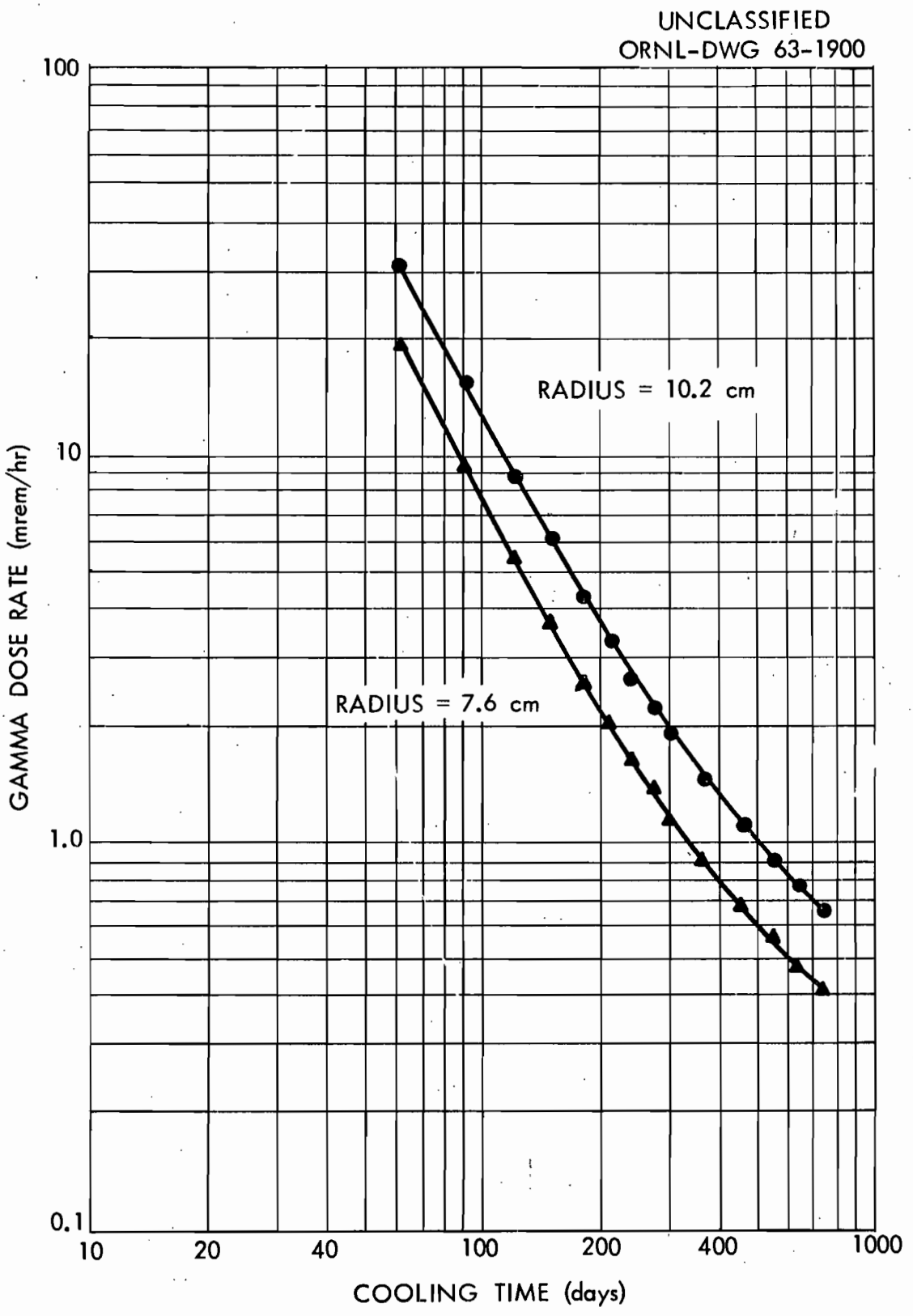

Fig. 6. The Effect of the Pot Radius on the Gamma Dose Rate from Purex in the Low Bay Cell.

Table 2. Comparisons of Gamma Dose Rates (mrem/hr) from Mechanical and Low Bay Cells with Similar Pot to Subject Distances

Comparison I		Comparison II	
Mechanical Cell	Low Bay Cell	Mechanical Cell	Low Bay Cell
Line D	Line A	Line C	Line B
Row 0	Row 0	Row 0	Row 0
Shield thickness = 121.9 cm	Shield thickness = 162.6 cm	Shield thickness = 121.9 cm	Shield thickness = 162.6 cm
Distance from center of pot to subject = 243.8 cm	Distance from center of pot to subject = 253.9 cm	Distance from center of pot to subject = 304.8 cm	Distance from center of pot to subject = 299.6 cm
	APPR Darex		
0.117	0.617	0.083	0.476
	Consolidated Edison Darex		
2.105	11.084	1.497	8.555
	Purex 7.6 cm Pot		
0.539	2.808	0.382	2.164
	Purex 10.2 cm Pot		
0.885	4.597	0.629	3.547

Note: In each comparison dose rates from one pot in each cell are considered.

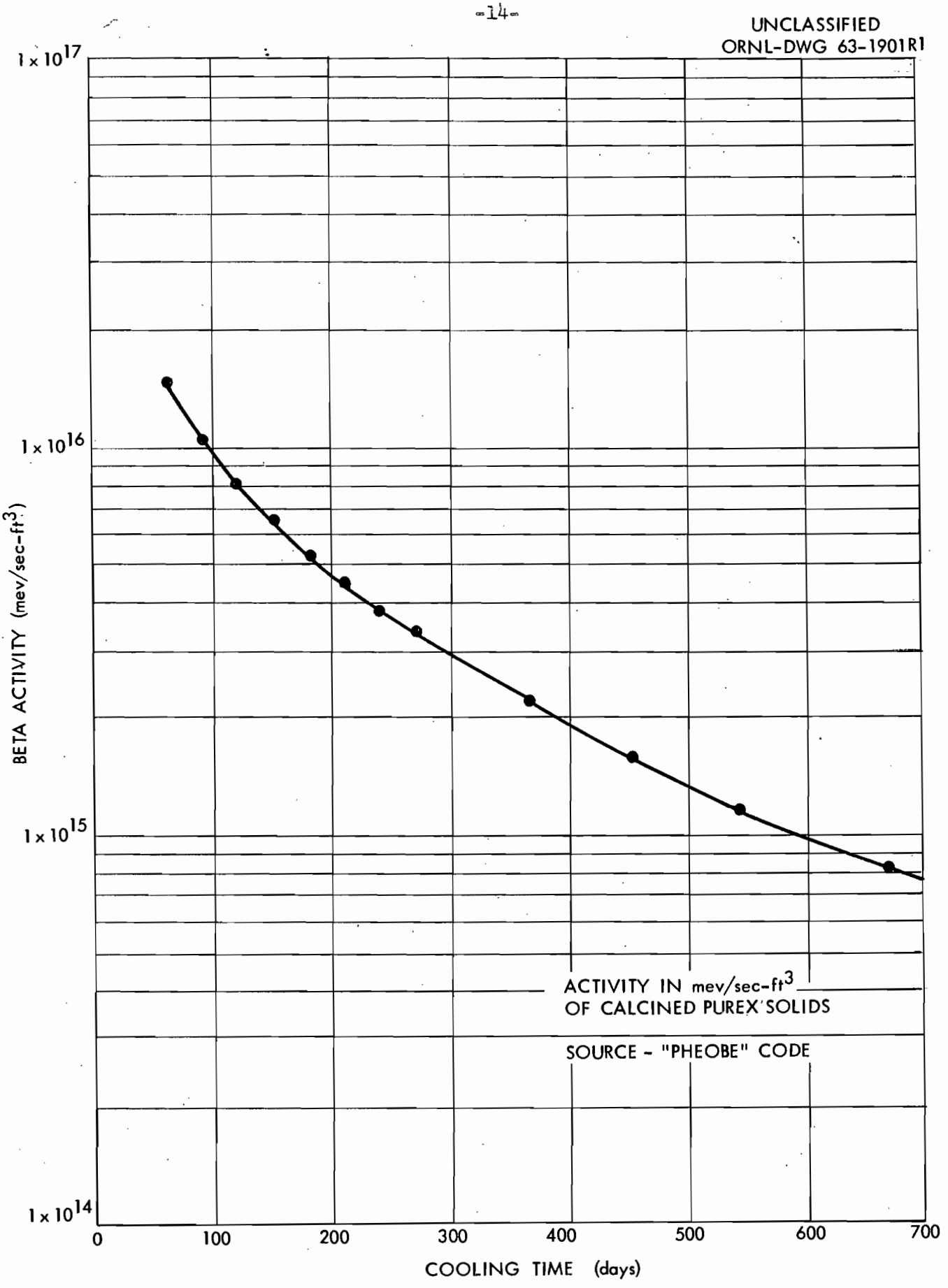

Fig. 7. Beta Activity in Purey Waste vs Cooling Time.

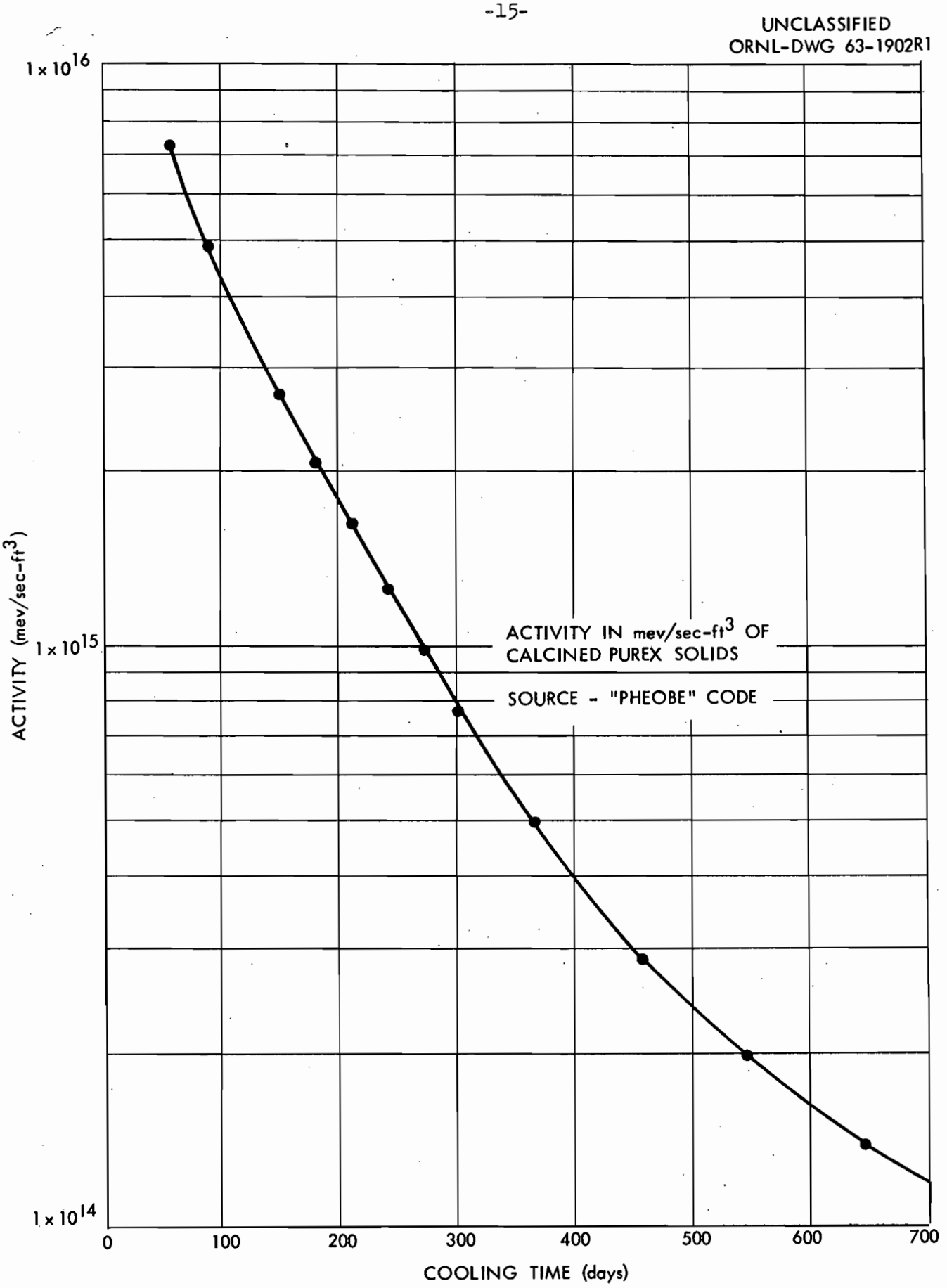

Fig. 8. Gamma Activity in Purex Waste vs Cooling Time.