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October 22, 1965

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EXTENDED PLUTONIUM IRRADIATION

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By Authority of RM Oten DR-24, 4-18-94

By DK Hanson, 5-9-94

Verified By J E Savely 5-13-94

By

P. D. Gross
Process Physics Unit
Process Technology Subsection
Research & Engineering Section

October 22, 1965

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

NOTICE

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EXTENDED PLUTONIUM IRRADIATION

INTRODUCTION

This document examines potential yields from extended irradiation of plutonium in a Hanford K reactor. The study was made using the MOFOA[1] program on the IBM-7090 Computer. Two types of plutonium were examined - weapons grade plutonium and plutonium from (.22 w/o U-235) depleted uranium irradiated to an exposure of about 2000 mwd/t. Both types of plutonium were irradiated for 3 years at an assumed 80 per cent operating efficiency.

RESULTS

The accompanying figures show build-up of the higher isotopes with irradiation time for both plutonium feeds. In each instance, the peak Pu-240 percentage (about 60 per cent) occurs after about 12 months irradiation. Also plotted are exposure, reactivity, power, Wescott cross-sections, Wescott R, neutron temperature, and Wescott flux of the plutonium column as a function of time. The absorption cross-section of Cm-244 used was 15 barns for the entire 36-month period. The reactivity plot shows the local worth of the plutonium column together with 9 surrounding natural columns relative to a natural column at goal exposure. The calculational model employs a four-group Wescott formulation. This treatment of the complex plutonium isotope resonance cross-section is of uncertain accuracy. However, self-shielding factors are included in the program. One example of a deviation from the expected results (probably due to the resonance treatment by the program) appears in the plot of local reactivity (Figure 3) where the reactivity of weapons grade plutonium should fall below that of plutonium from depleted uranium as soon as the w/o Pu-241 is in the same range as the w/o Pu-239. However, this occurs too soon; and the relative reactivities again reverse so that after 24 months, the weapons grade plutonium again appears more reactive than that from depleted uranium. The resonance integral was calculated to be about 280 for both weapons grade plutonium and plutonium from depleted uranium during the 36-month period.

CALCULATION

The plutonium elements were designed so that the OD of the can provided sufficient flow annulus for an initial column power of about 2170 kw.[2] A solid element was used with a 1.455" can OD and a 1.355" core OD. The column (together with the nine surrounding natural uranium columns to form the supercell) was then irradiated in three-month steps for three years.

It was calculated that the initial fuel concentration necessary for a 2170 kw column power would be 3.30 per cent weapons grade plutonium (94 per cent Pu-239 and 6 per cent Pu-240) or 4.34 per cent plutonium from depleted uranium (72.2 per cent Pu-239, 23.2 per cent Pu-240, 3.9 per cent Pu-241, and 0.7 per cent Pu-242) in the aluminum matrix.

---

[1] MOFDA - an engineering-physics program written by R. O. Gumprecht for use on the IBM-7090 or UNIVAC-1107 Computers.

[2] Personal communication - P. A. Carlson to P. D. Gross, June 28, 1965.

[redacted]

A base reactivity of zero was assumed for a K5 natural column at goal exposure and the reactivity plot (Figure 3) shows the deviation from this base.

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Process Physics Unit
Process Technology Subsection
Research & Engineering Section

PD Gross:cwi

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FIGURE 1
EXPOSURE OF PLUTONIUM COLUMN
AS A FUNCTION OF TIME IN-REACTOR

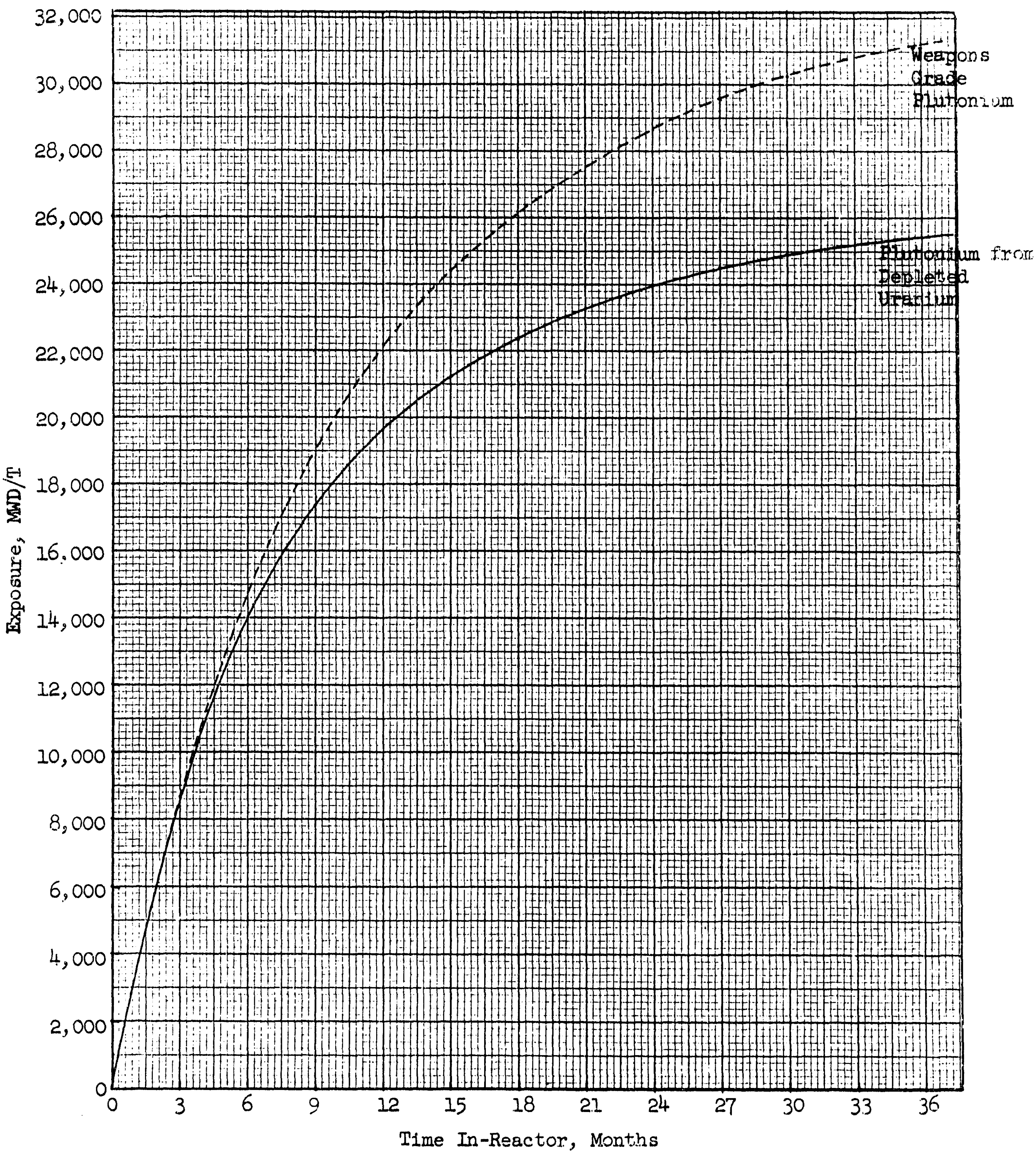

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FIGURE 2
PLUTONIUM TARGET COLUMN POWER AS A FUNCTION OF TIME

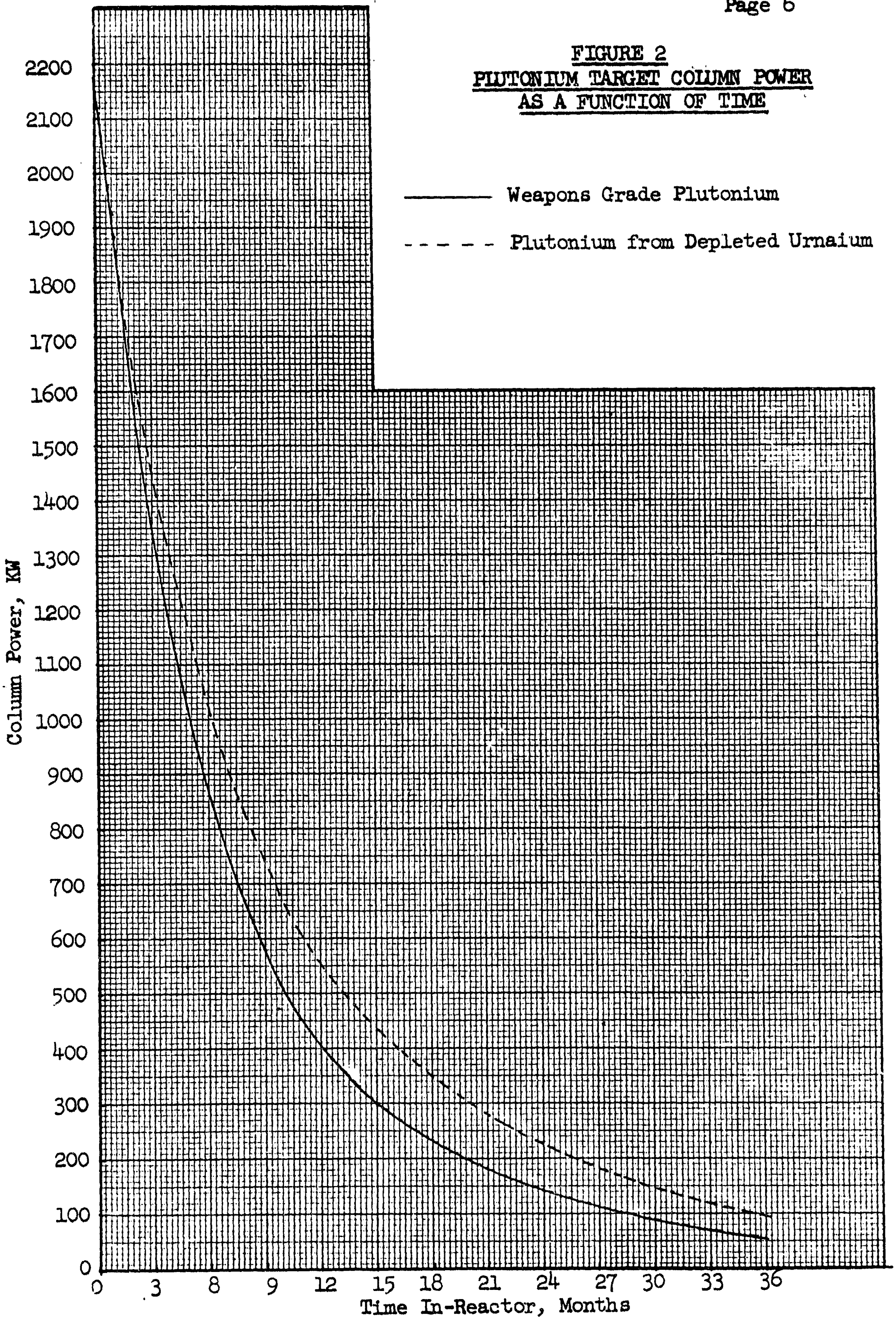

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FIGURE 3
LOCAL REACTIVITY OF PLUTONIUM COLUMN
AND 9 SURROUNDING NATURAL COLUMNS AS A FUNCTION OF TIME IN-REACTOR

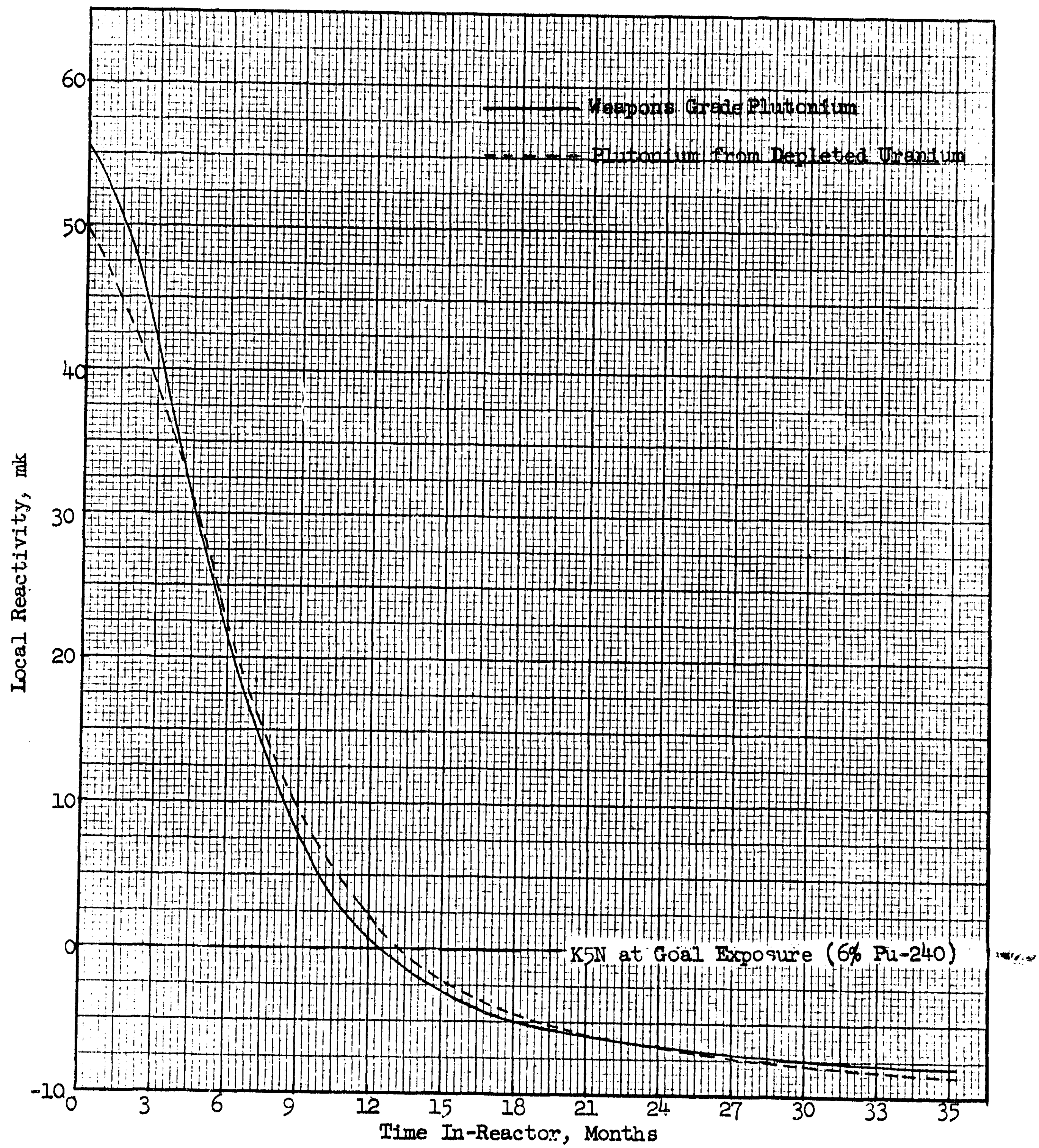

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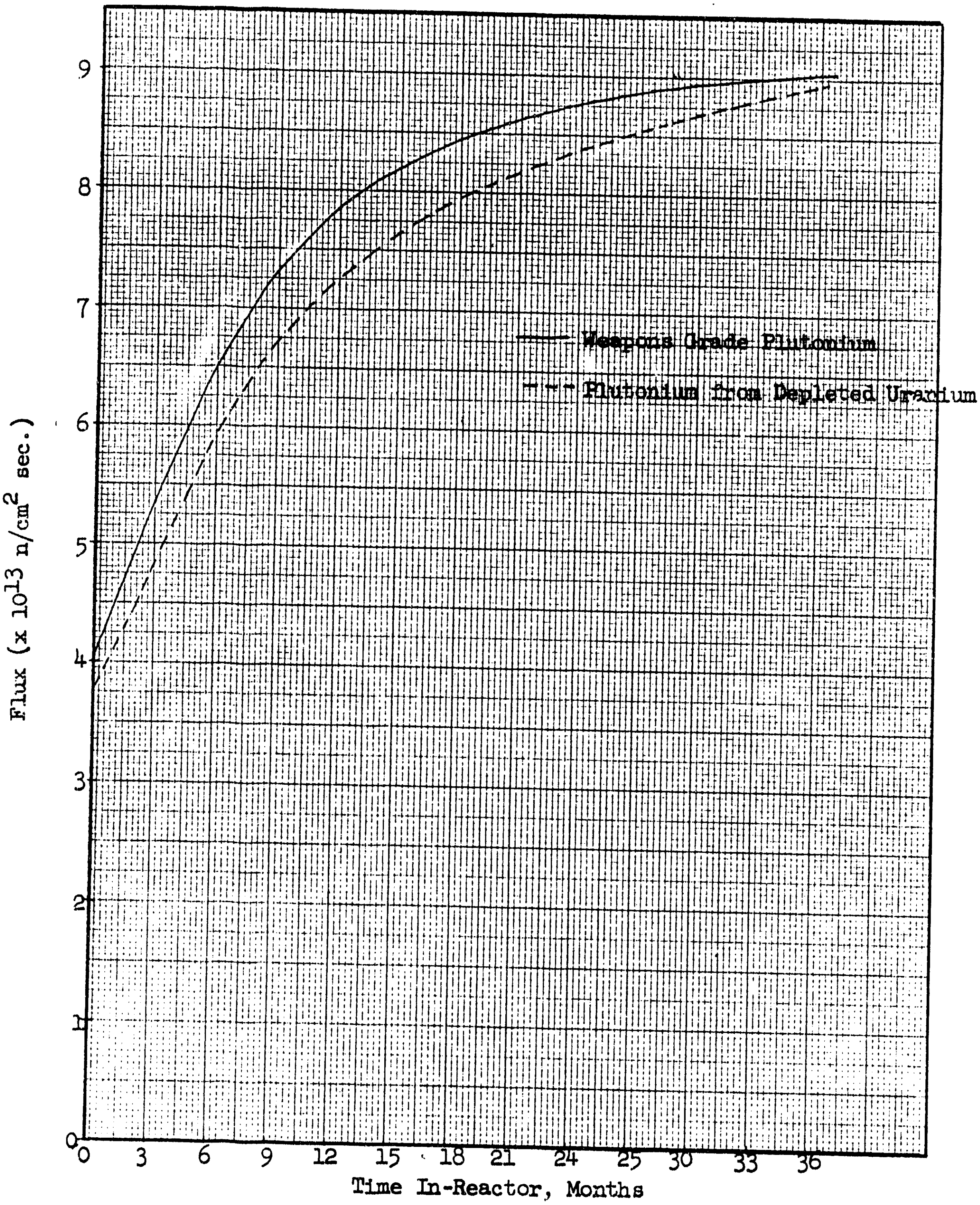
FIGURE 4
WESCOTT FLUX IN CENTER PLUTONIUM ELEMENT
AS A FUNCTION OF TIME IN-REACTOR



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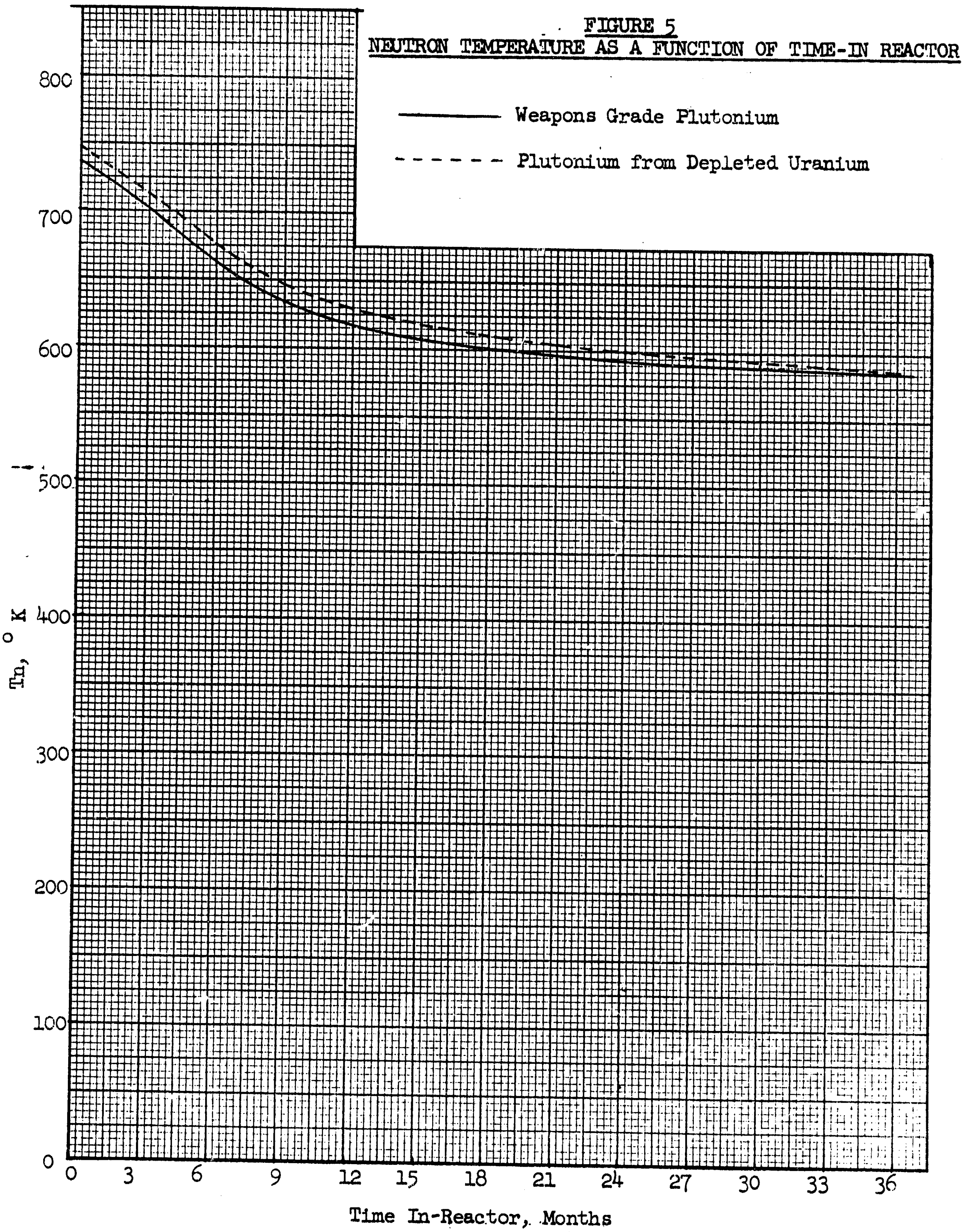

FIGURE 5
NEUTRON TEMPERATURE AS A FUNCTION OF TIME-IN REACTOR

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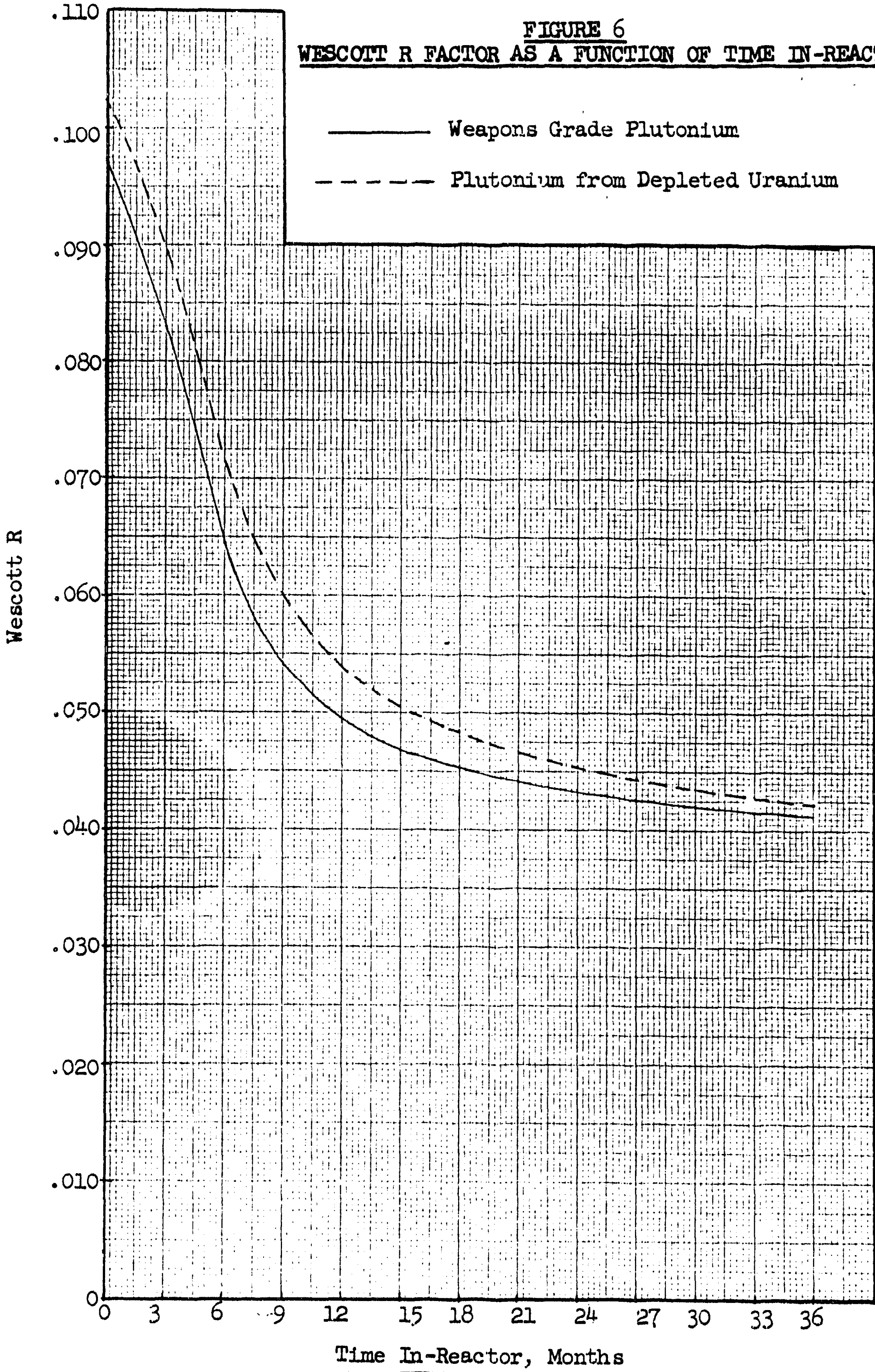
FIGURE 6
WESCOTT R FACTOR AS A FUNCTION OF TIME IN-REACTOR



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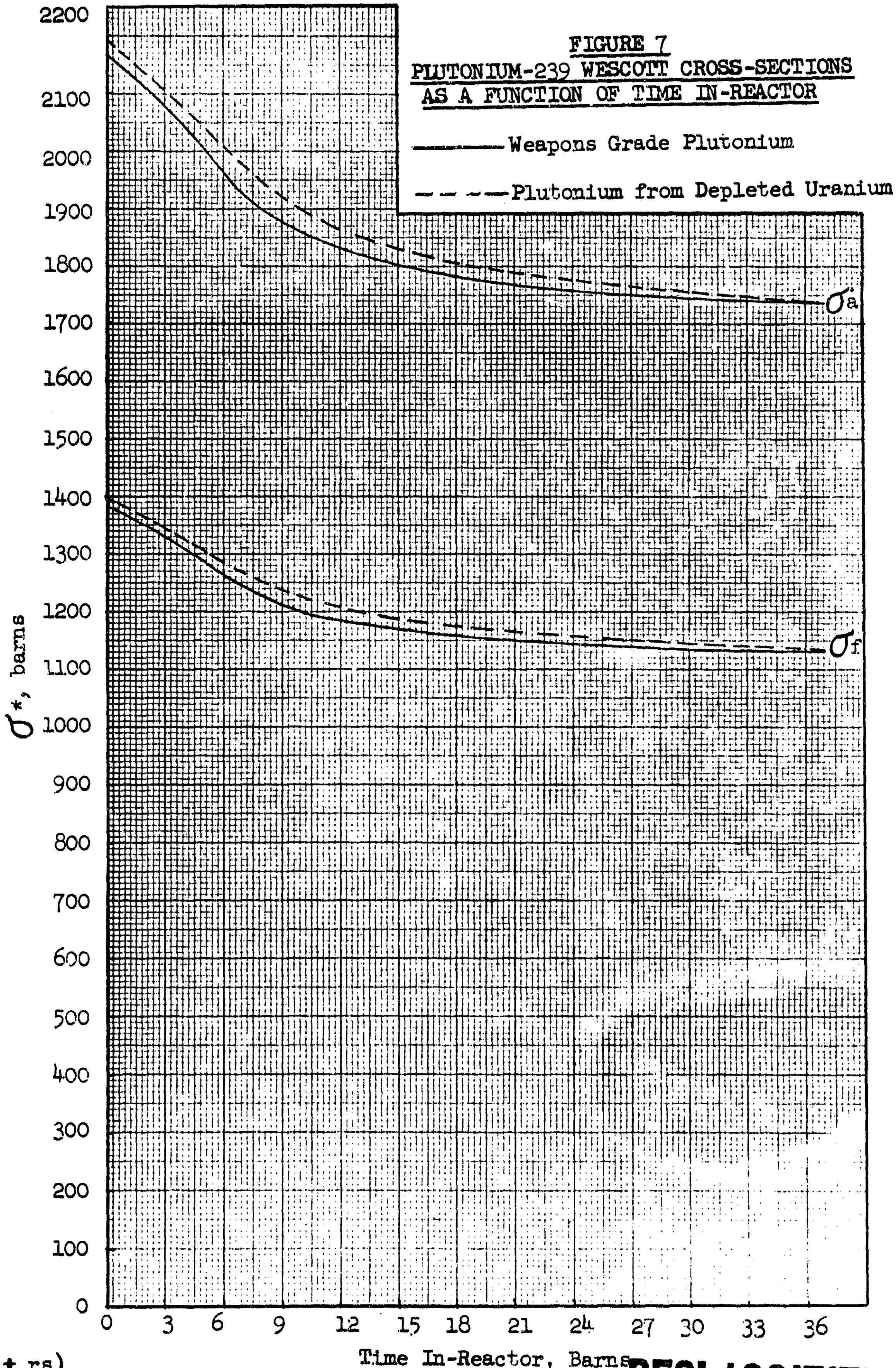
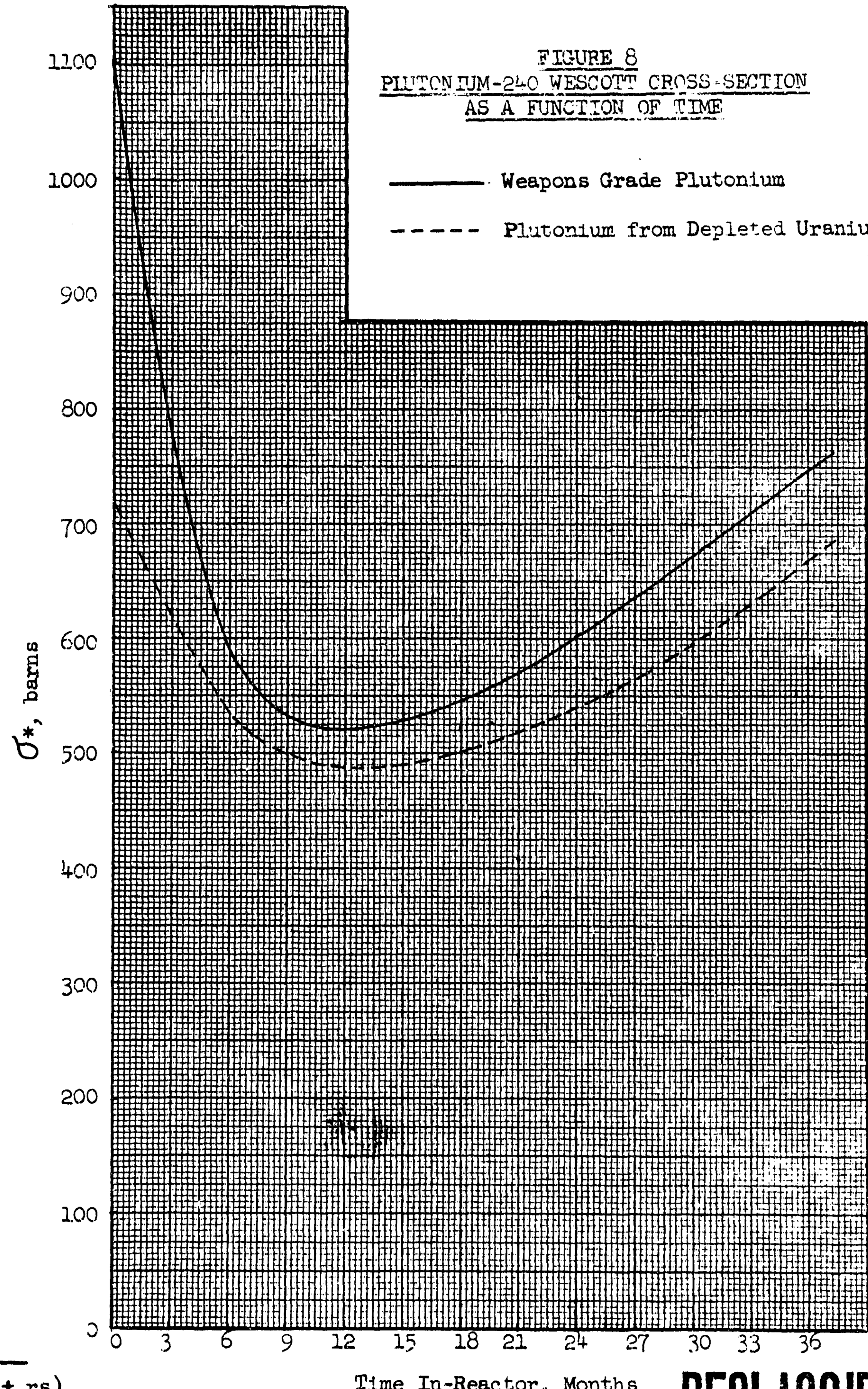


FIGURE 7
PLUTONIUM-239 WESCOTT CROSS-SECTIONS AS A FUNCTION OF TIME IN-REACTOR

$^*\sigma_{2200}$ (g + rs)

[redacted]

FIGURE 8
PLUTONIUM-240 WESCOTT CROSS-SECTION
AS A FUNCTION OF TIME



$* \sigma_{2200}$ (g + rs)

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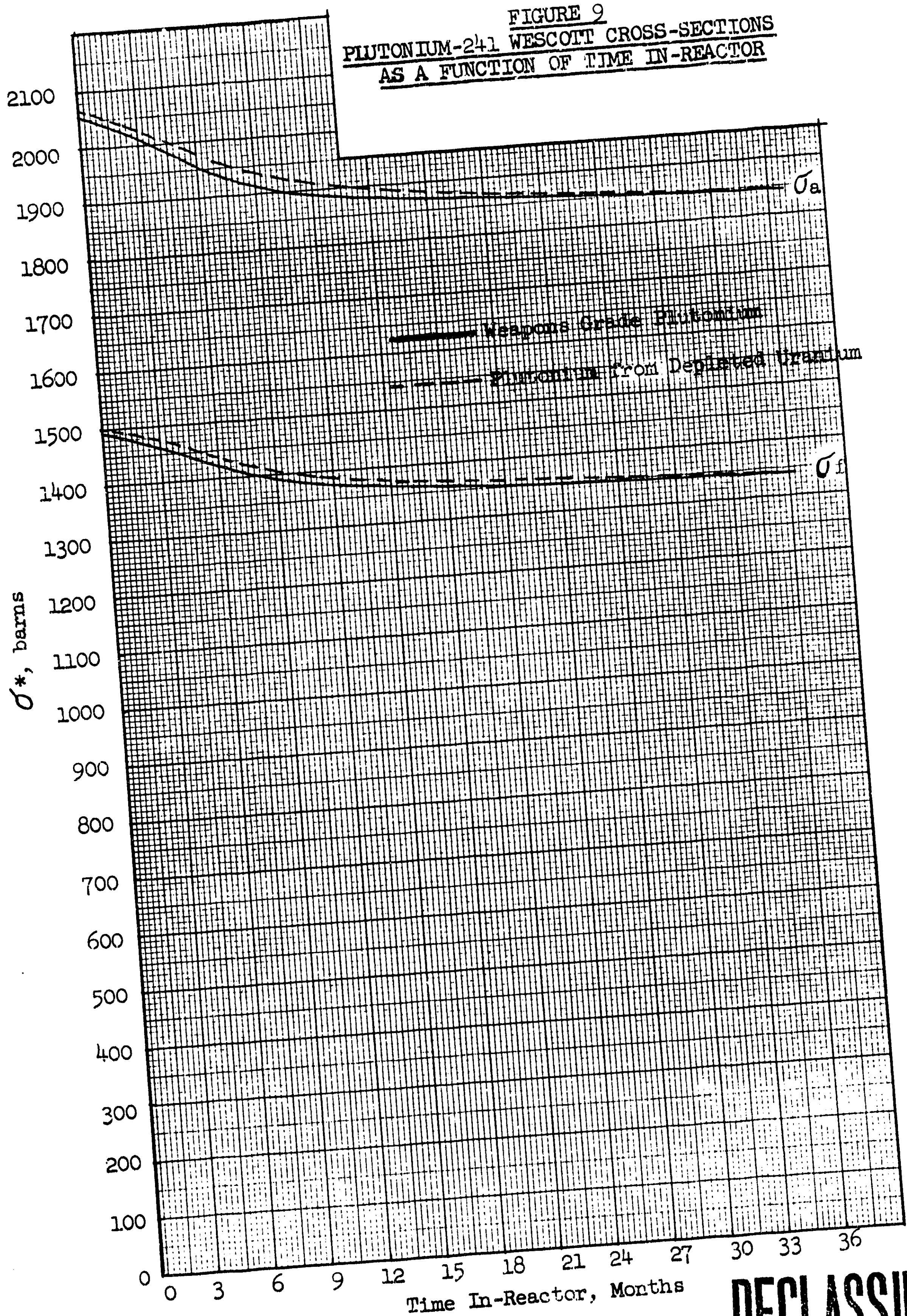
FIGURE 9
PLUTONIUM-241 WESCOTT CROSS-SECTIONS
AS A FUNCTION OF TIME IN-REACTOR



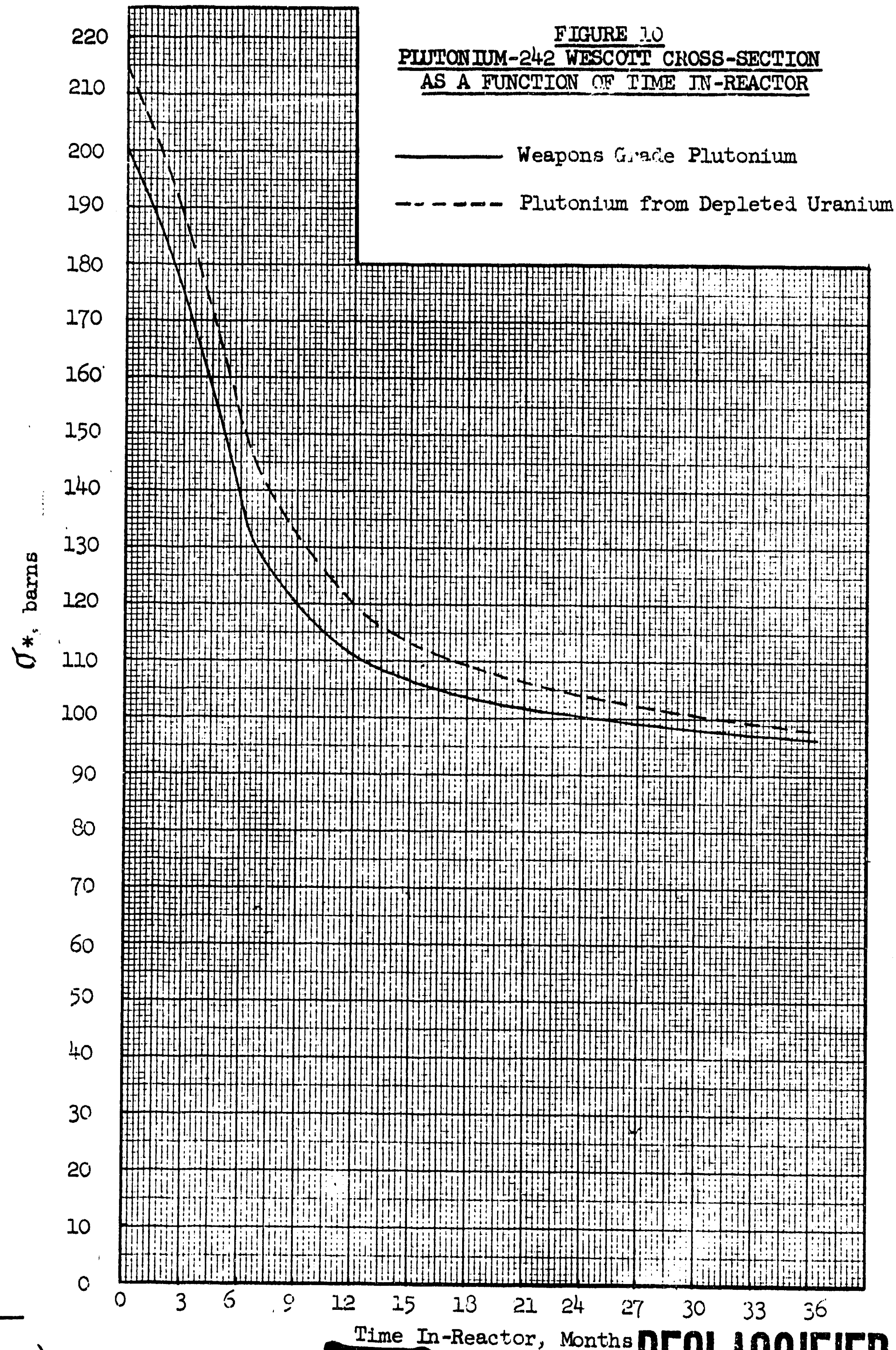


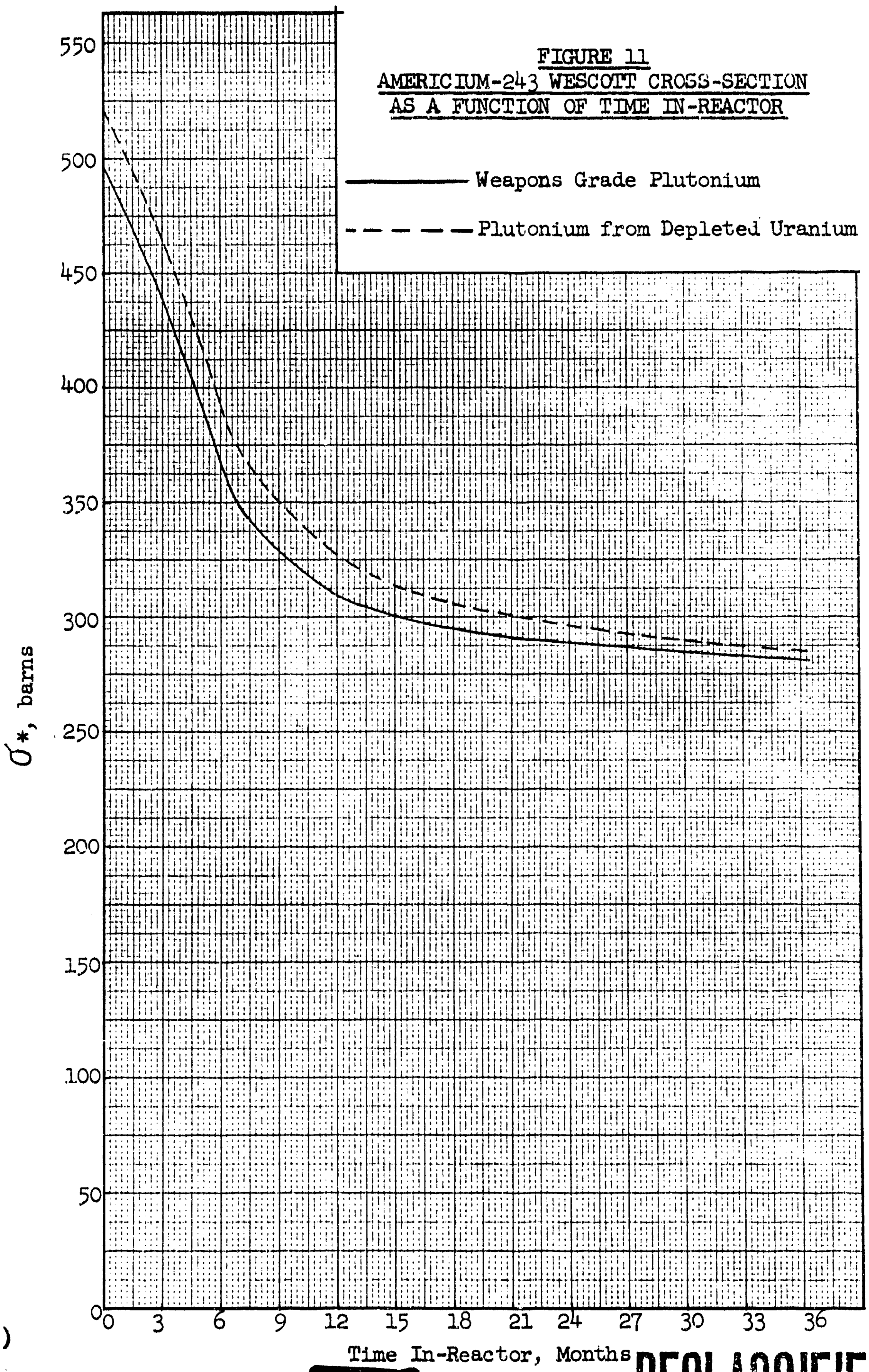
FIGURE 10
PLUTONIUM-242 WESCOTT CROSS-SECTION AS A FUNCTION OF TIME IN-REACTOR

* σ_{2200} (g + rs)

[redacted]

[redacted]

FIGURE 11
AMERICIUM-243 WESCOTT CROSS-SECTION
AS A FUNCTION OF TIME IN-REACTOR



* σ_{2200} (g + rs)

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FIGURE 12
RATIO OF PLUTONIUM TO INITIAL PLUTONIUM
AS A FUNCTION OF TIME IN-REACTOR

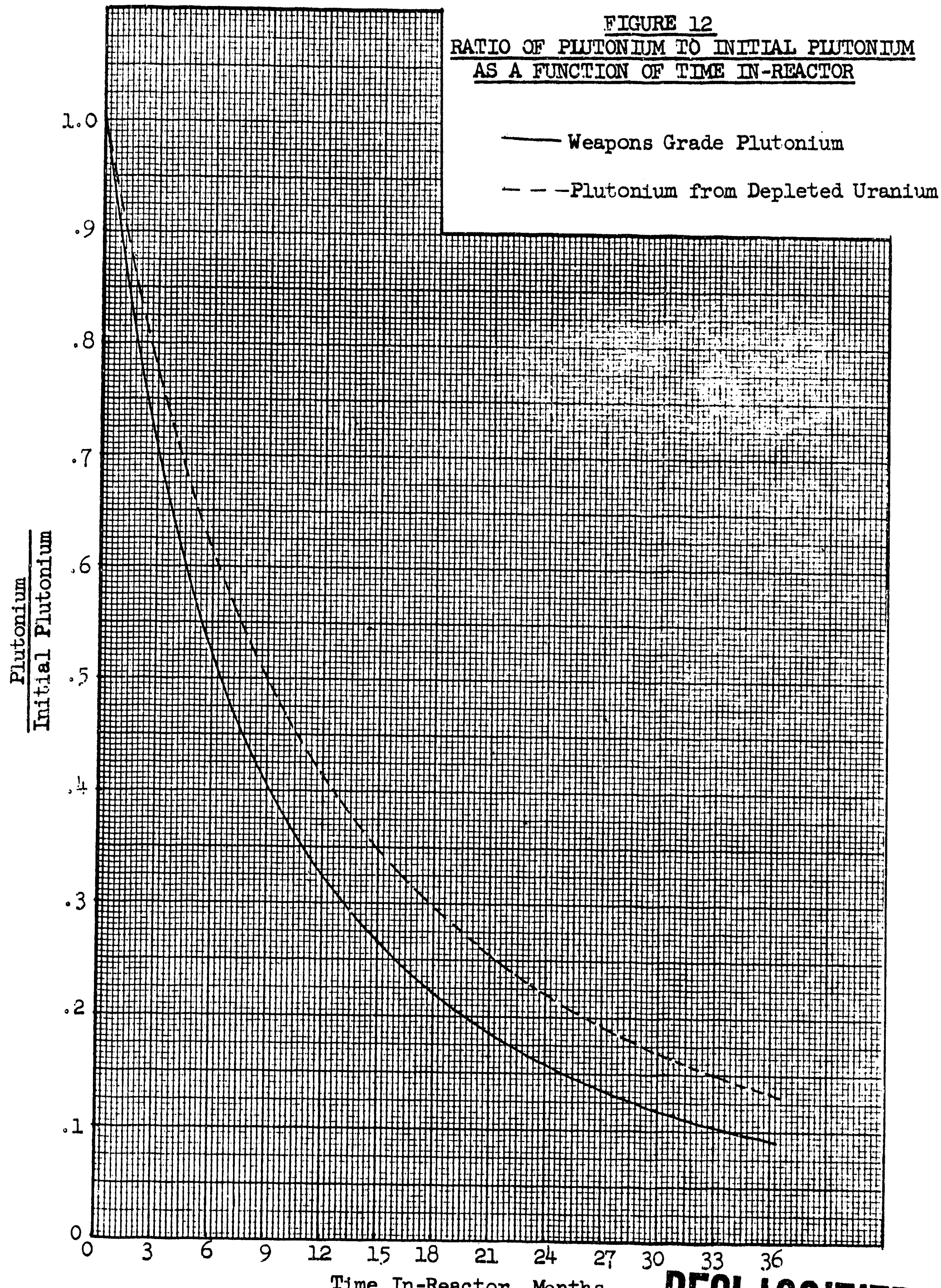

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FIGURE 13
ATOMIC PER CENT PU-239
AS A FUNCTION OF TIME IN-REACTOR

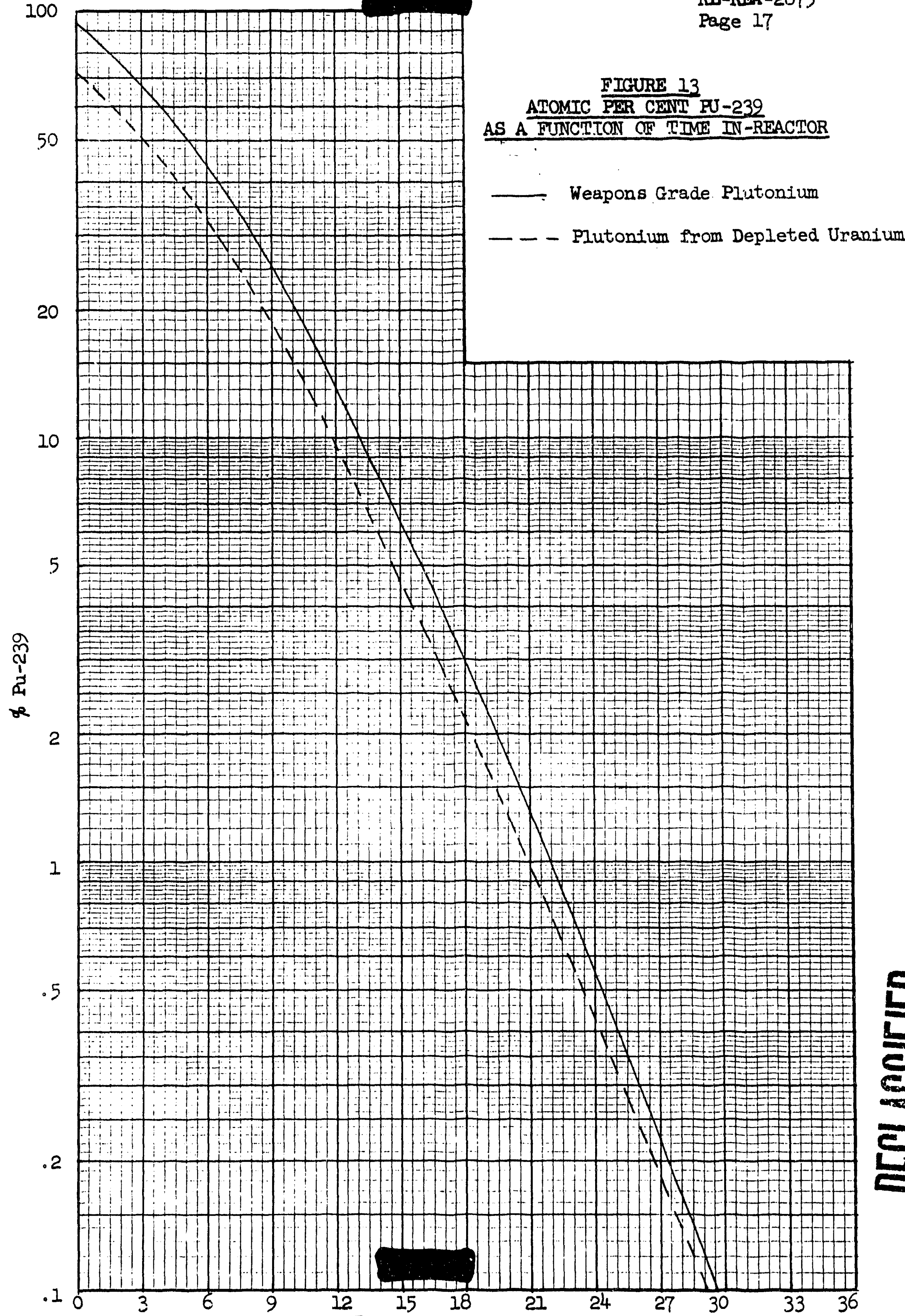

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FIGURE 14
ATOMIC PER CENT PU-240
AS A FUNCTION OF TIME IN-REACTOR

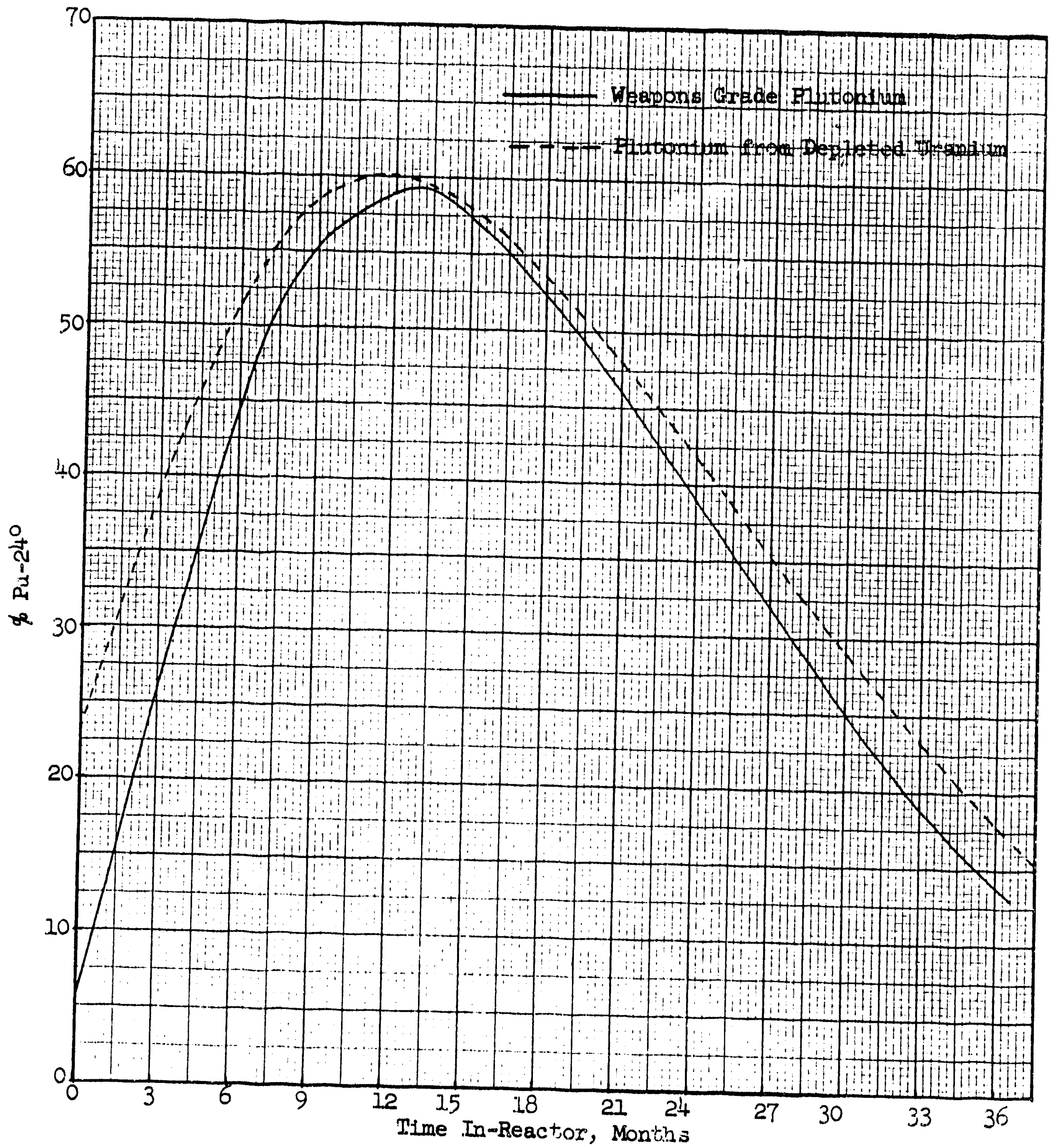

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FIGURE 15
ATOMIC PER CENT PU-241
AS A FUNCTION OF TIME IN-REACTOR

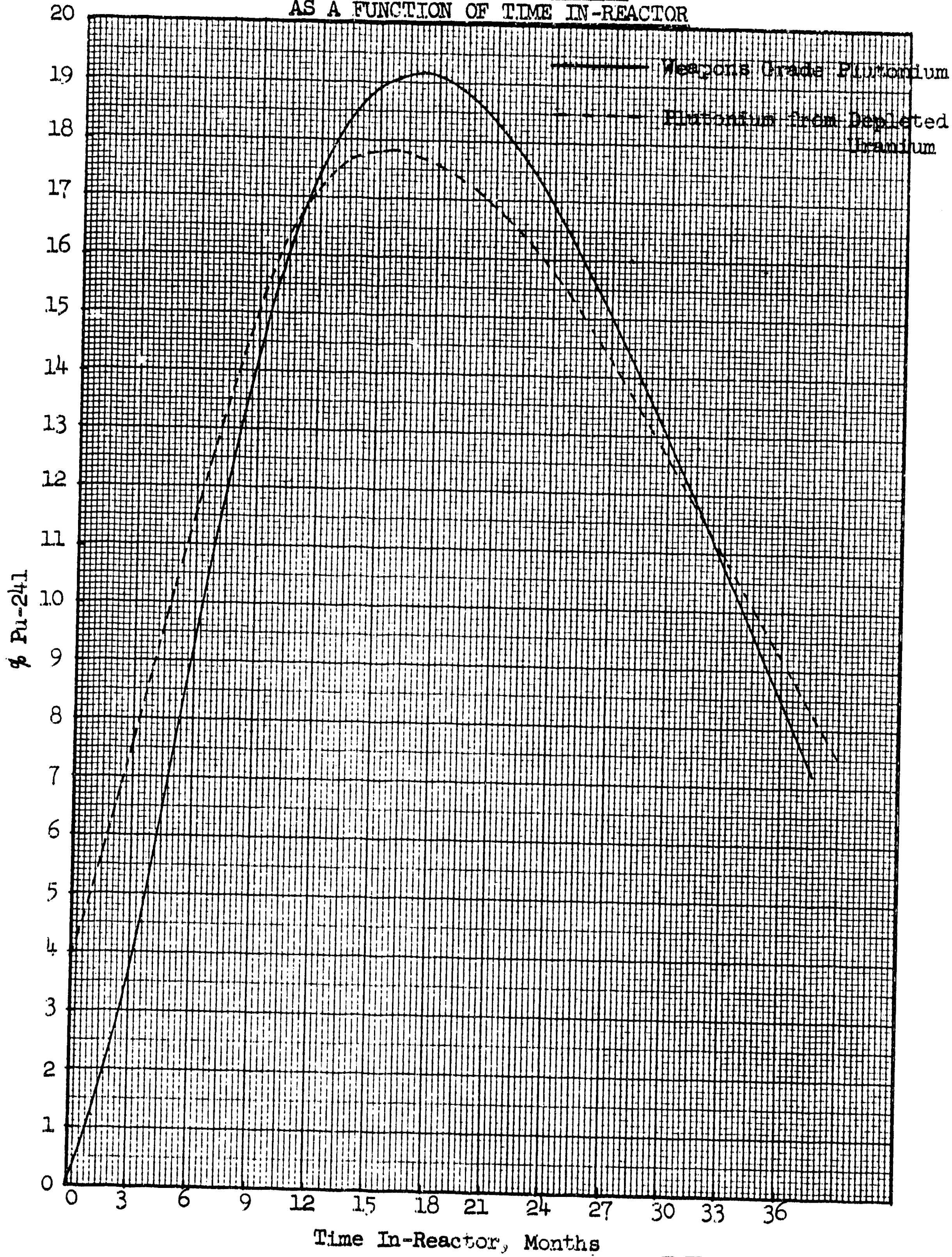

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FIGURE 16
ATOMIC PER CENT PU-242
AS A FUNCTION OF TIME IN-REACTOR

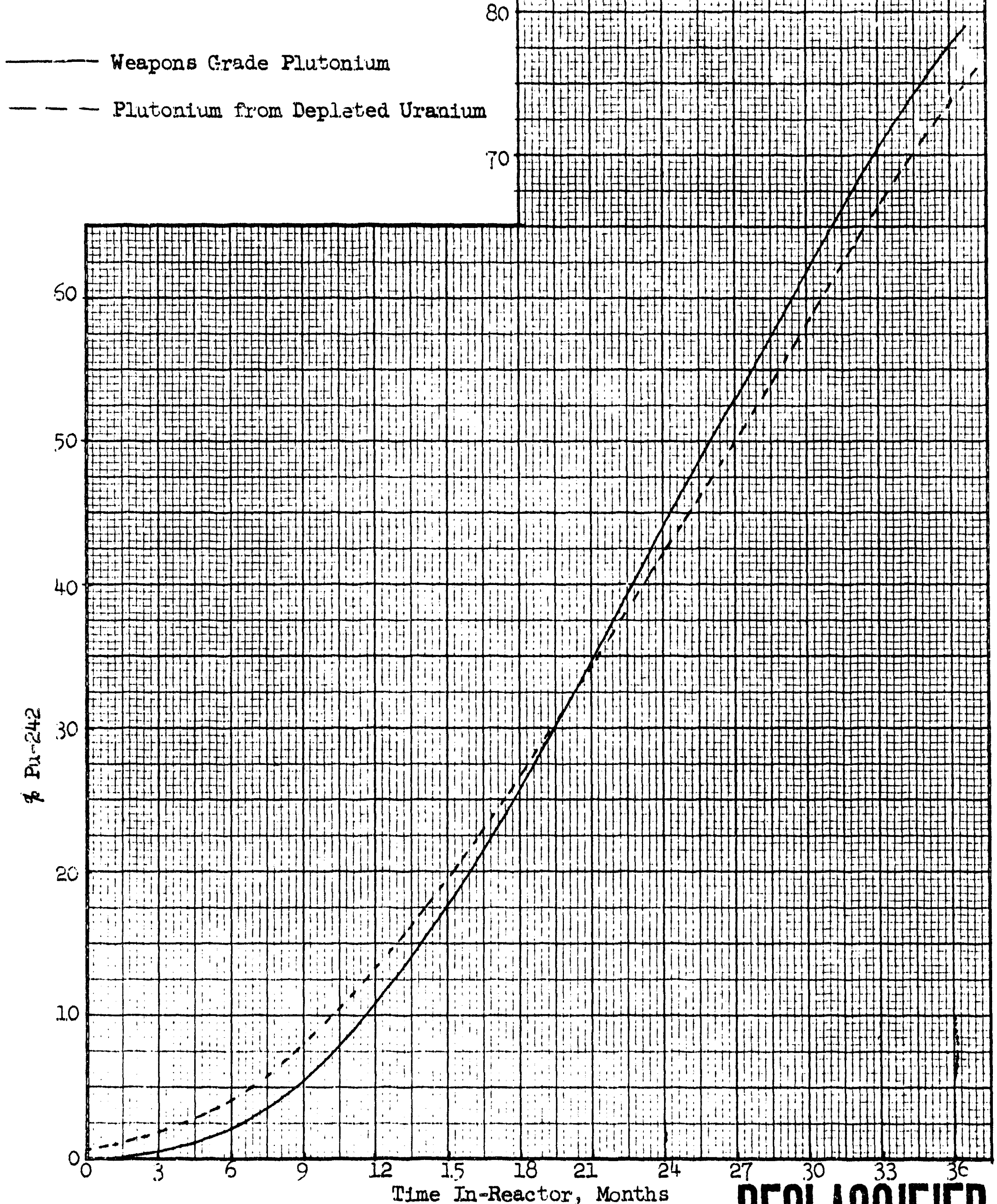

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FIGURE 17
WEIGHT PER CENT PU-239 (BASED ON 100 W/O PU AT START) AS A FUNCTION OF TIME IN-REACTOR

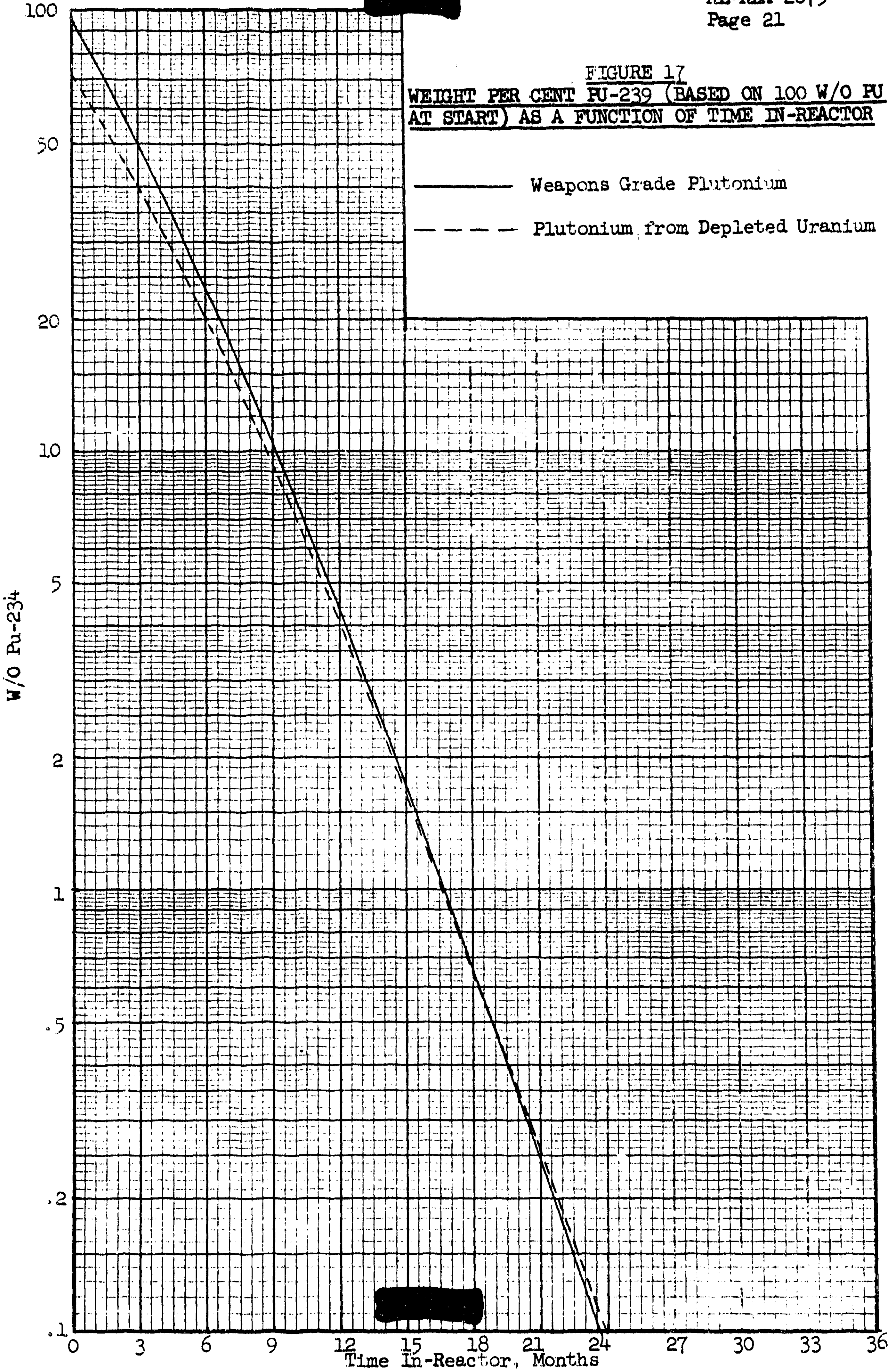

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FIGURE 18

WEIGHT PER CENT PU-240 (BASED ON 100 W/O PU AT START) AS A FUNCTION OF TIME IN-REACTOR

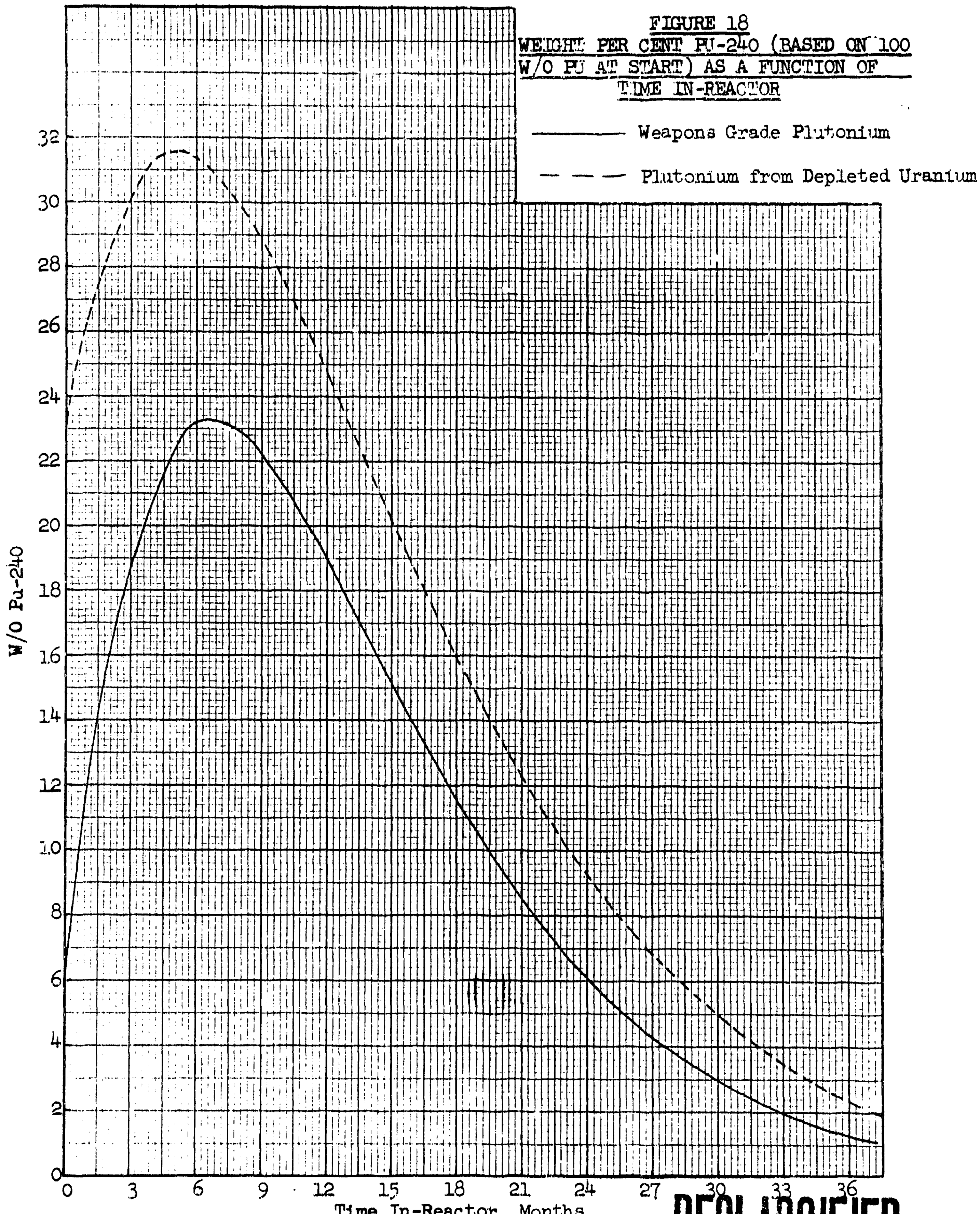

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FIGURE 19
WEIGHT PER CENT PU-241 (BASED ON 100 W/O PU AT START) AS A FUNCTION OF TIME IN-REACTOR

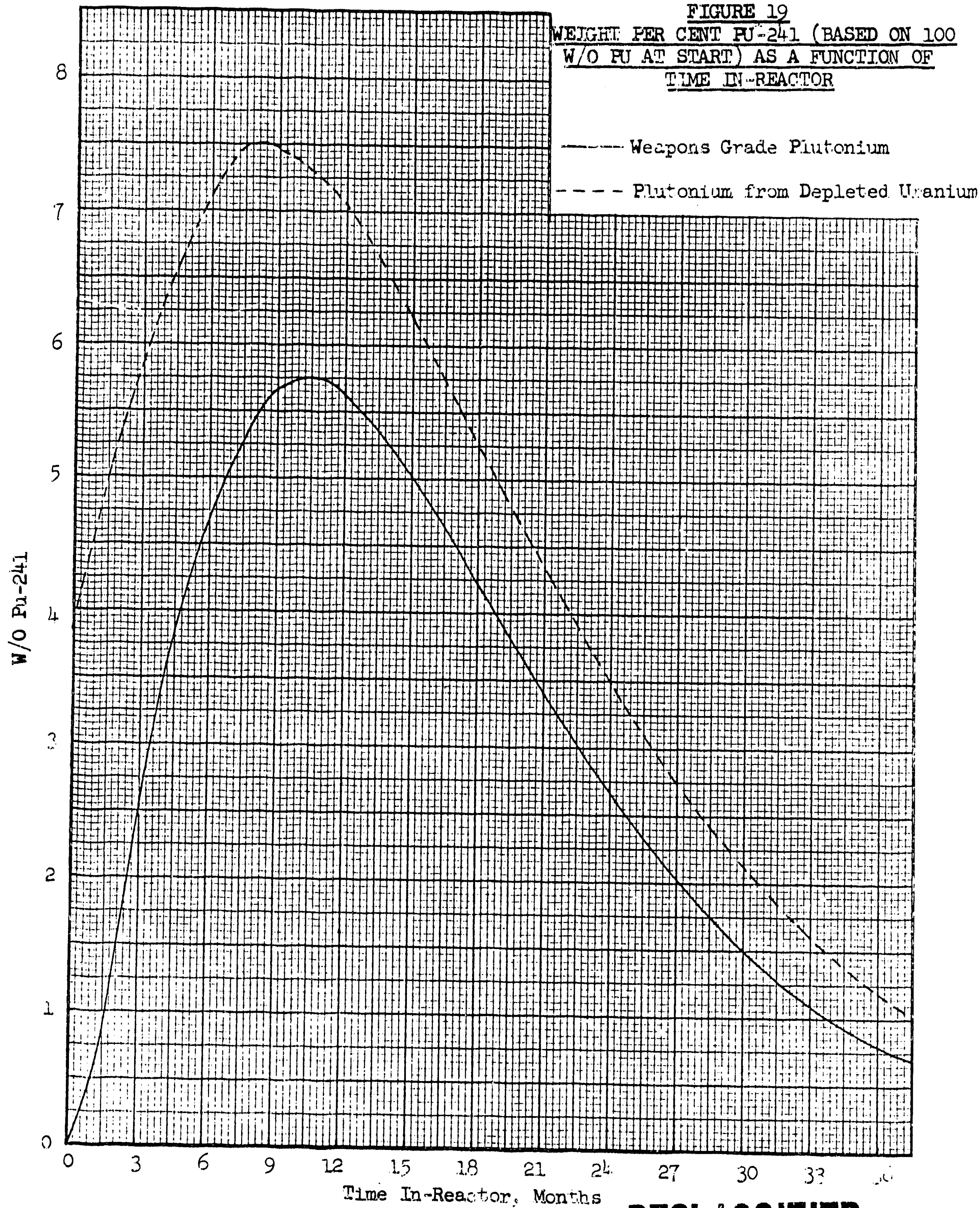

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FIGURE 20
WEIGHT PER CENT PU-242 (BASED ON 100 W/O PU AT START)
AS A FUNCTION OF TIME IN-REACTOR

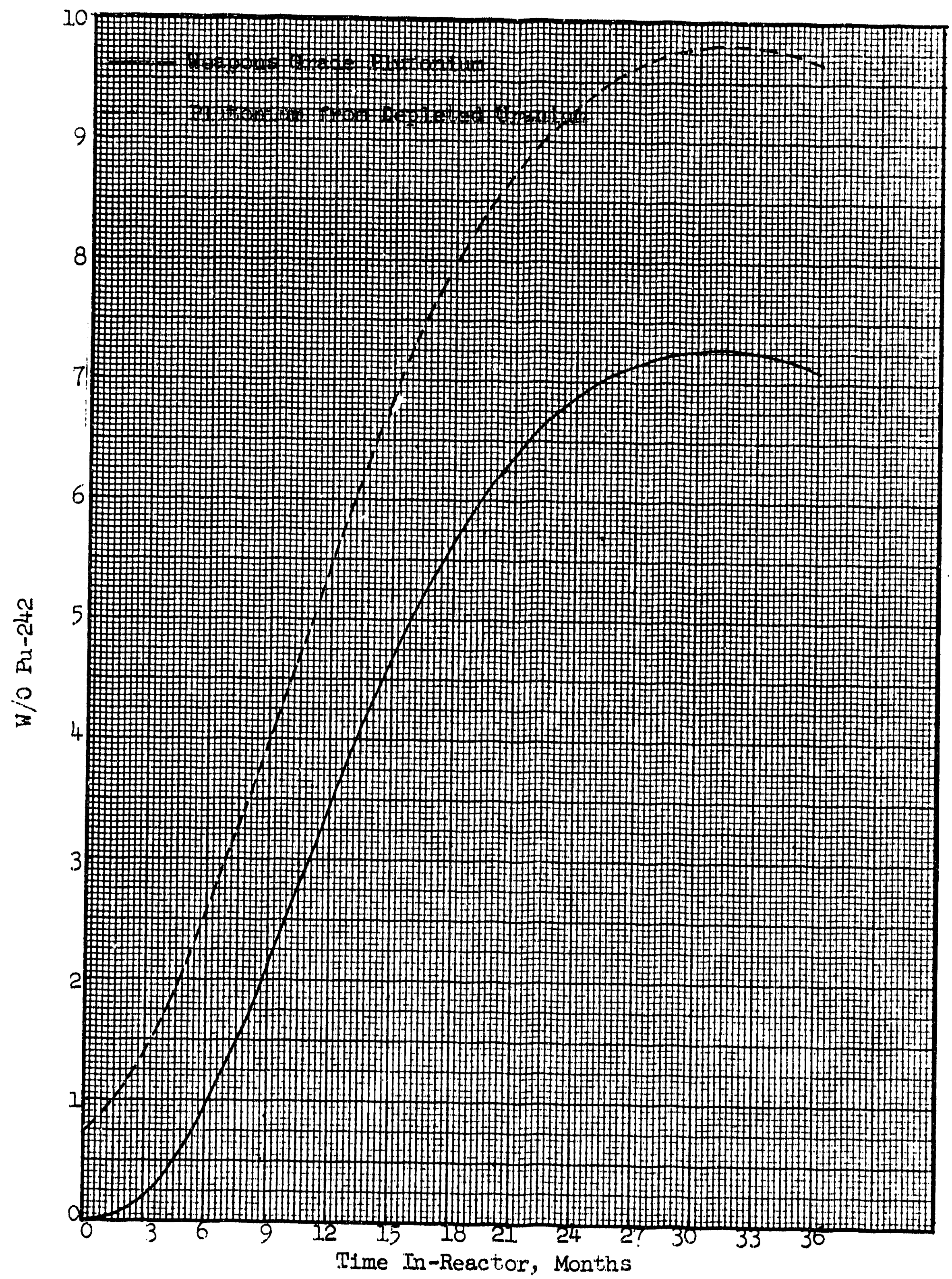

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FIGURE 21
WEIGHT PER CENT AM-243 (BASED ON 100 W/O PU AT START)
AS A FUNCTION OF TIME IN-REACTOR

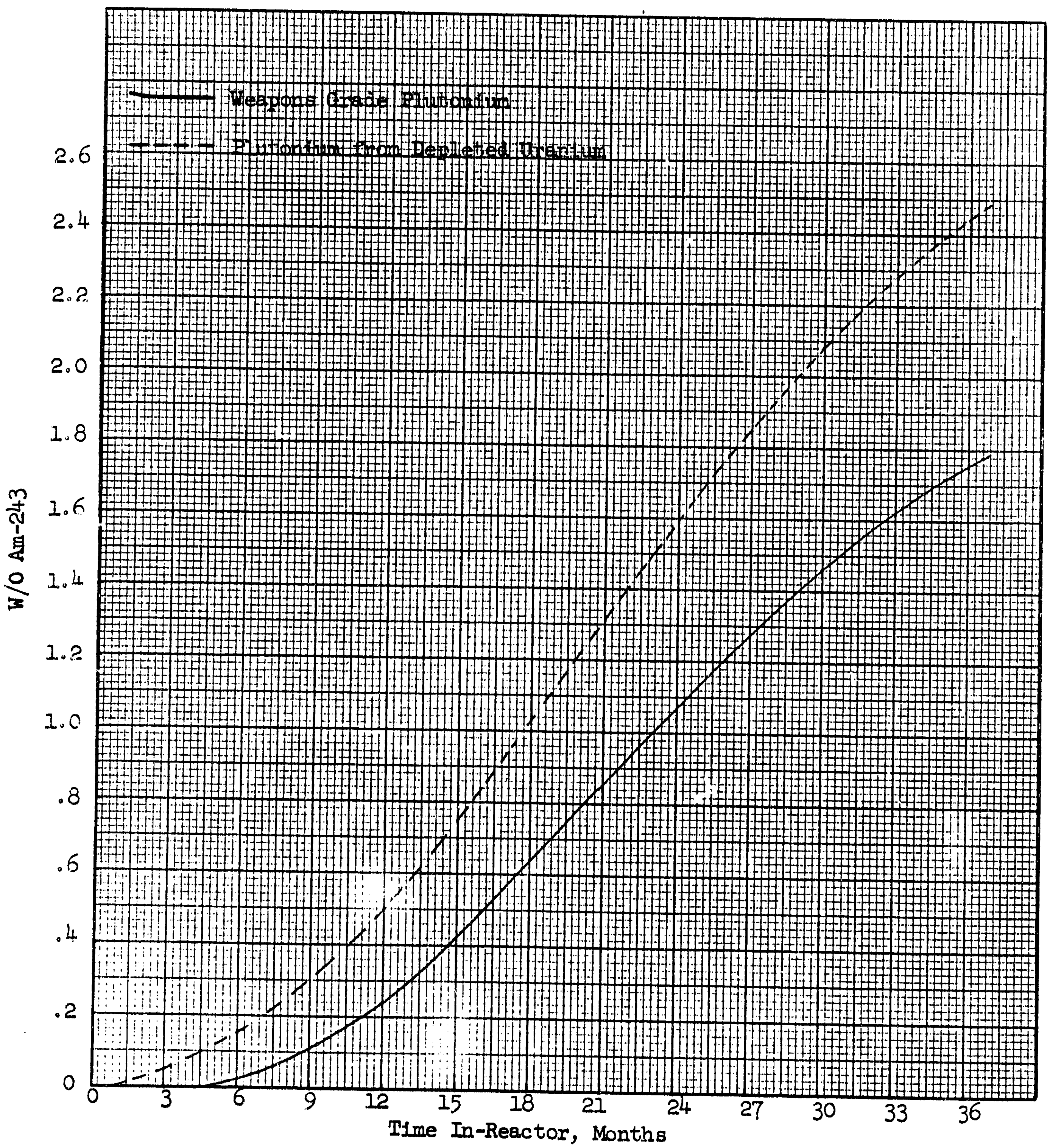

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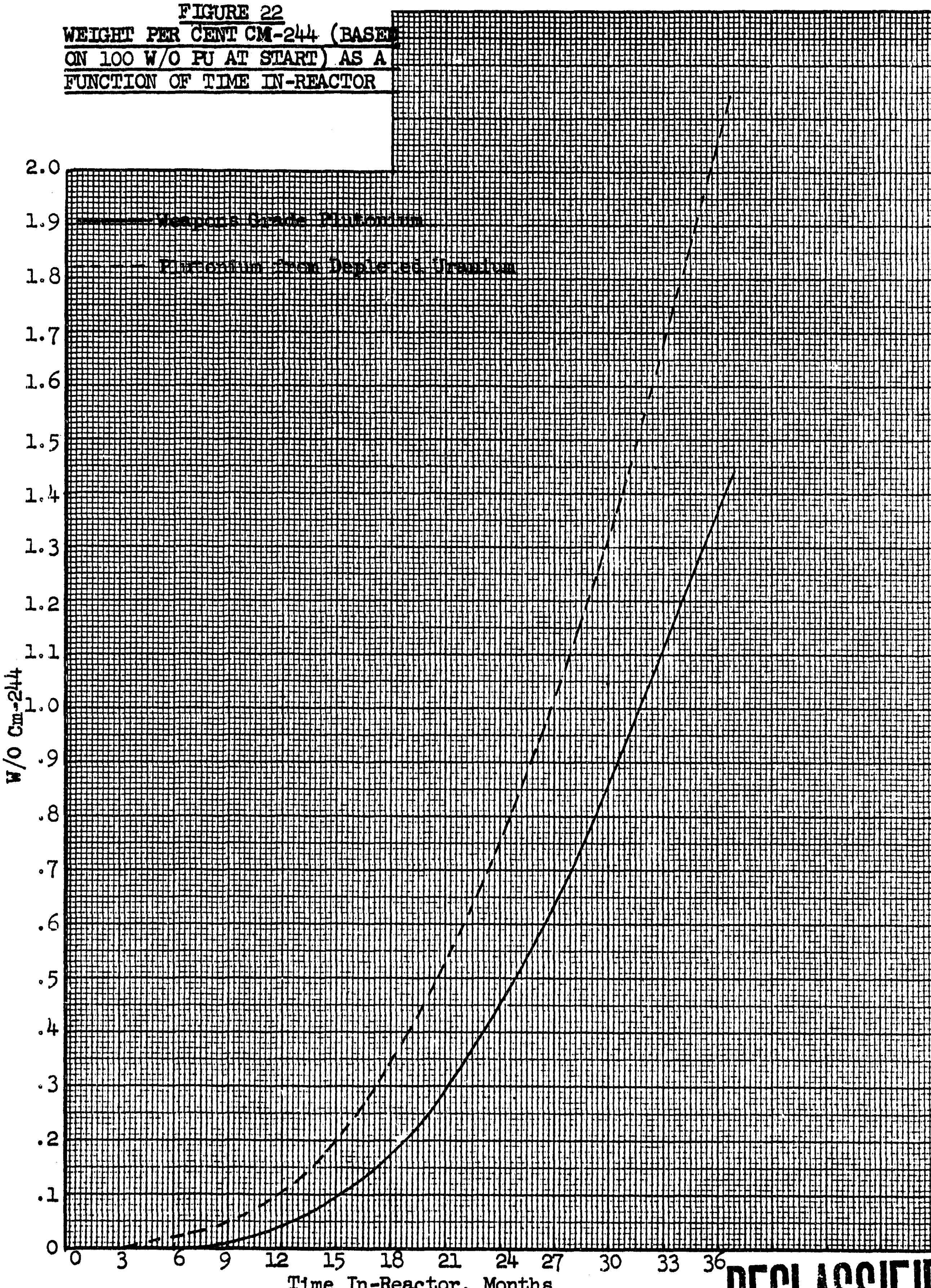
FIGURE 22

WEIGHT PER CENT CM-244 (BASED ON 100 W/O PU AT START) AS A FUNCTION OF TIME IN-REACTOR



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