control

INV. 62

Campbell

M-49-A

Erratum

DO NOT REMOVE THIS PAGE

Classification changed to: UNCLASSIFIED

By Authority of: TID-1109

By: ORNL Libraries Division
Y-12 Technical Library
Document Reference Section
Building 9711-1

Date: OCT 1 '56

X-906

REPORT NO. MOU P-379
This document contains 1 Pages of Text and 1 Pages of Figures.
This is copy 25 of 79 Series A.

ISSUED TO: Gale Young

THIS IS A CLASSIFIED DOCUMENT

[redacted]

...n the individual will be relieved
...safe-keeping.
... routing this report and must be
... it.

...o	Read by	Date	Route to

ORNL LIBRARIES DIVISION
Y-12 TECHNICAL LIBRARY
Document Reference Section

LOAN COPY ONLY

Do NOT transfer this document to any other person. If you want others to see it, attach their names, return the document, and the Library will arrange the loan as requested.

[redacted]

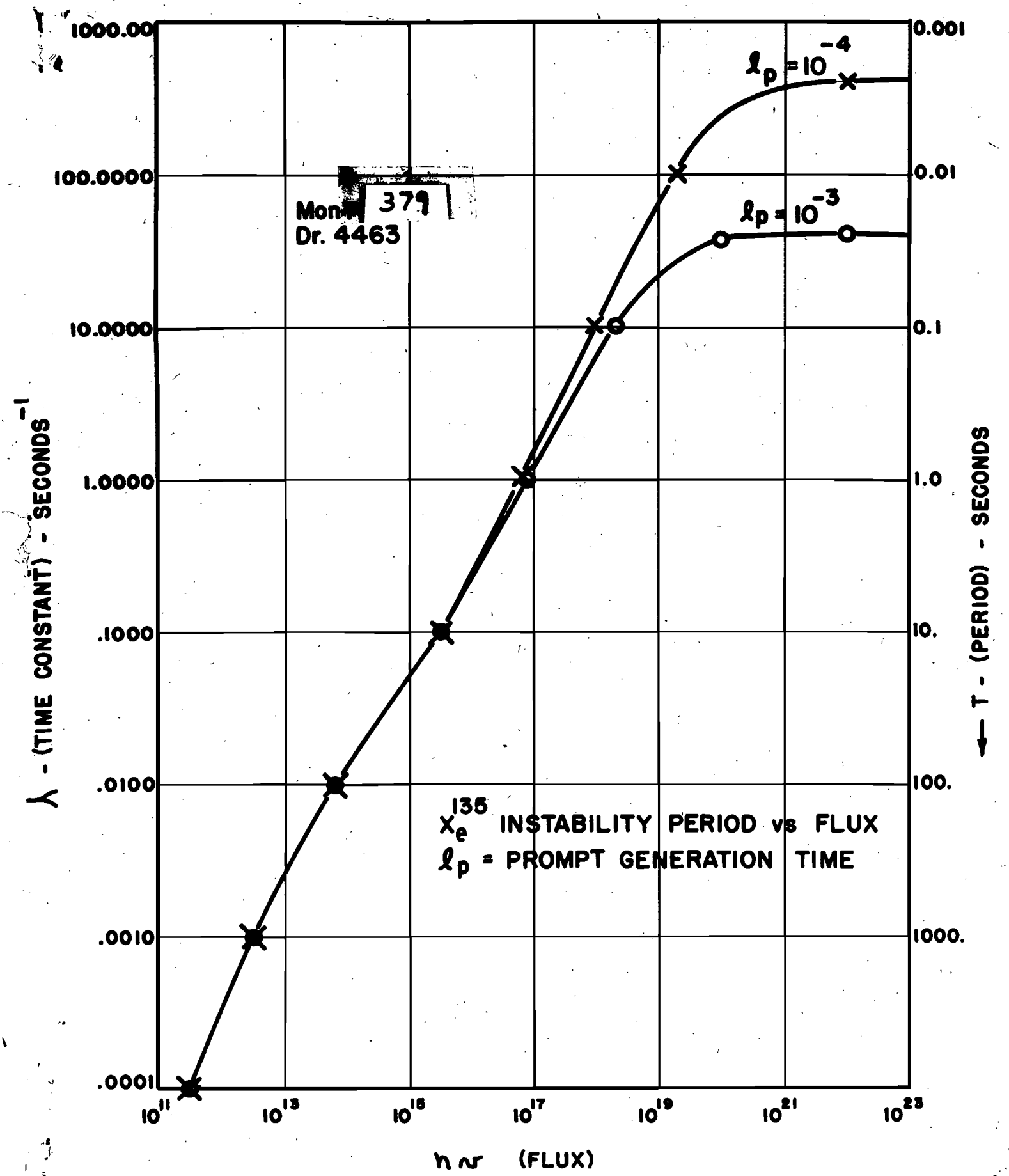
October 3, 1947

Addenda to MonP-379

Please attached the enclosed drawing to your copy of Report MonP-379.

Enclosure: Dwg. #4463

[redacted]



Mon[redacted] 379
Dr. 4463

[redacted]

M-49-A

DO NOT REMOVE THIS PAGE

SECRET

REPORT NO. Man P-3 79
This document contains 6
Pages of Text and 8 Pages
of Figures.
This is copy 25 of 79 Series
A.

ISSUED TO: Gale Mumma

[redacted]

Route to	Read by	Date	Route to	Read by	Date	Route to

SECRET

[redacted]

Mon-P-379

Contract No. W-35-058, eng. 71

* * * * * * * * * *

* * * * * *

XENON INSTABILITY PERIODS AS A FUNCTION OF FLUX IN THERMAL PILES

By:

K. O. Donelian and J. R. Menke

September 10, 1947

Date Received: 9/30/47 Date Issued: 9/30/47

[redacted]

Xenon Instability Periods as a Function of Flux in Thermal Piles

K. O. Donelian and J. R. Menke

The significance of Xe^{135} on the stability of piles has been investigated on various occasions by F. L. Friedman, H. Soodak, G. P. Nordheim, L. N. Nordheim and others. This memorandum examines the dependence of the xenon period on flux level with a view towards defining practical flux domains for future piles as determined by xenon. Cooperation by H. Soodak in checking the method and A. S. Householder's computing staff for numerical calculations, is gratefully acknowledged.

Method

If dynamic behavior of a thermal pile due to xenon alone is considered, solution by perturbation methods of the four basic equations of motion: (nomenclature, Pg. (4))

$$\frac{d\phi}{dt} = \frac{\phi}{\ell_p}(\rho - \rho_x - \beta k) + \frac{c}{\ell_d} \tag{1a}$$

$$\frac{dc}{dt} = \frac{\phi\beta k}{\ell_p} - \frac{c}{\ell_d} \tag{1b}$$

$$\frac{dx}{dt} = I\lambda_I - x\lambda_x - \phi\sigma_x x \tag{1c}$$

$$\frac{dI}{dt} = \phi\,\varepsilon_f\,Y - I\lambda_I - \left[\phi\sigma_I\, I \cong 0\right] \tag{1d}$$

gives a cubic equation (2) for λ

$$\lambda\left[1 + \frac{\beta k}{\ell_p(\lambda + \frac{1}{\ell_d})}\right] = \frac{(\phi\sigma_x)^2\, Y}{\ell_p(\lambda + \lambda_x + \phi\sigma_x)(\lambda_x + \phi\sigma_x)} \tag{2}$$

where λ is defined as the reciprocal period (equation (3))

$$\phi = \phi_o\, e^{\lambda t} \tag{3}$$

SECRET

Results

When plotted, equation (2) yields the curves shown on the attached graph sheet demonstrating saturation for instability periods for fluxes beyond 10^{20} and cut off below 10^{12}. Two typical values for ℓ_p have been assumed in these calculations, 10^{-3} secs and 10^{-4} secs.

The general expression for λ can be considerably simplified for the following narrow regions of interest.

(1) when $\phi \leq 10^{12}$

$$\lambda \cong 0$$

(2) when $\phi \cong 10^{14}$

$$\lambda \cong \sqrt{\frac{Y \phi \sigma_x}{\ell_p + \beta k \ell_d}} = \sqrt{\frac{Y}{\tau_{eff}\, \tau_x}}$$

where $\tau_{eff} = \ell_p + \beta k \ell_d$, the effective neutron lifetime

$\tau_x = \phi \sigma_x$, the xenon "lifetime" determined by the neutron flux.

(3) when $\phi \cong 10^{17}$

$$\lambda \cong \frac{-\beta k + \sqrt{(\beta k)^2 + 4\ell_p Y \phi \sigma_x}}{2\ell_p}$$

(4) when $\phi \geq 10^{20}$

$$\lambda \cong \frac{Y - \beta k}{\ell_p} = \text{constant.}$$

Remarks

In this treatment, certain simplifying assumptions have been made which appear justified for a first order study of the problem.

a. In writing the equations of motion for the pile we have assumed an infinite pile, i.e. one with a flat flux distribution, and have neglected all second order effects due to space-time functions of flux. Only the fundamental mode or motion of the pile as a whole is considered.

b. Delayed neutrons are considered as a single group with a mean average delay period of 10 seconds, βk assumed $= 0.01$ for calculations.

SECRET

[redacted]

c. In the calculations and graphs, two values for ℓ_p, the prompt generation time, have been considered. For high fluxes, thermal considerations will point toward considerable dilution of active material and therefore generation times of 10^{-3} seconds appear proper. For more concentrated geometries, operating at lower fluxes, lifetimes of 10^{-4} seconds are possible and have been included in this study.

d. At the flux levels for which xenon instability becomes interesting, the instability period for the pile is considerably smaller than the decay period for I^{135}. Hence we neglect changes in I^{135} concentration during the perturbation period.

e. This study considers pile stability as affected by xenon alone. A detailed study including stabilizing factors such as thermal effects on density and nuclear properties of pile constituents would in most cases present a more accurate and perhaps more optimistic picture. In spite of this rather important omission, future flux levels as high as 10^{16} do not appear impossible from a xenon instability point of view. It is clear that other considerations (such as heat transfer and radiation stability of materials) require critical study and may well be limiting before xenon.

[redacted]

[redacted]

Nomenclature

ϕ — Flux (nv)

ℓ_p — prompt generation time

ρ — change in pile reactivity due to all effects other than Xe^{135} (ρ assumed = 0 in this discussion)

ρ_x — change in pile reactivity due to Xe^{135}

$$\rho_x = \frac{(x - x_o)\,\sigma_x}{\mathcal{E}_f + (x - x_o)\sigma_x} \cong \frac{(x - x_o)\,\sigma_x}{\mathcal{E}_f}$$

β — combined delayed neutron fraction - assumed $\beta k = 0.01$ for calculations.

k — multiplication factor (see β above)

c — combined concentration of delayed neutron emitters

ℓ_d — mean average delay time for delayed neutrons - assumed $\ell_d = 10$ sec. for calculations.

x — Xe^{135} concentration

λ_x — reciprocal decay period for Xe^{135} (3×10^{-5} sec^{-1})

σ_x — cross section in barns for Xe^{135} (3×10^6 barns)

I — I^{135} concentration.

λ_I — reciprocal decay period for I^{135}

$\mathcal{E}_f$ — macroscopic fission cross section

Y — fission yield of I^{135} (0.05 for I^{135}) (fission yield of Xe^{135} assumed = 0)

λ — reciprocal instability period

[redacted]

RECEIVED
MAY 26 1948
OAK RIDGE NATIONAL
LABORATORIES
CENTRAL FILES

SEP 1947
Clinton Laboratories
Central File
Room

ORNL