THE DEPENDENCE OF ACTIVATION UPON THE PULSE FORM IN A PULSED NEUTRON GENERATOR

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If the neutron yield during a pulse is fixed, the activity of the sample at the end of pulse will depend on the pulse shape. Using a suitable pulse form, the experimenter can increase the irradiation result for a given sample and a fixed neutron yield.

Neutron pulses are usually of approximately rectangular form.\textsuperscript{1–5} Rectangular pulses, however, do not correspond to the most economic exploitation of the target. Golański has recently reported that a triangular pulse produces the same activity as a rectangular one if the neutron yield of the former is 20% lower than that of the latter.\textsuperscript{2}

However, two different triangular pulses with the same neutron yield will also produce different activities. In addition, the effectiveness of a neutron pulse depends on the pulse length-to-T ratio.

The foregoing statements result from the known expression for the activity produced in a variable neutron flux:

\begin{equation}
a(t) = N \sigma \lambda e^{-\lambda t} \int_0^T \Phi(t) e^{\lambda t} dt, \quad (1)
\end{equation}

where \( t \) – pulse length,
\( \Phi(t) \) – neutron flux as a function of time \( t \),
\( N \) – number of nuclei of irradiated element.

For the three pulse forms shown in Fig. 1, the activities of the sample at the end of the irradiation (at constant neutron yield) will be equal to:

\begin{equation}
a_1(t) = \Phi_0 \sigma N (1 - e^{-\lambda t}), \quad (2)
\end{equation}

\begin{equation}
a_2(t) = \Phi_0 \sigma N \left(1 - e^{-\frac{\lambda t}{2}}\right)^2, \quad (3)
\end{equation}

\begin{equation}
a_3(t) = 2\Phi_0 \sigma N \left(1 - \frac{1 - e^{-\lambda t}}{\lambda t}\right). \quad (4)
\end{equation}
The relationships between the activities \( a_1(\tau) \), \( a_2(\tau) \) and \( a_3(\tau) \) and the ratio \( \tau/T \) are illustrated in Fig. 2.

In the case when \( T \ll \tau \), the efficiency of the triangular pulse 3 is about twice as high as that of the rectangular pulse 1.

The next question is: what neutron pulse form is the most effective? To answer this problem let us consider the two pulse shapes shown in Fig. 3. The neutron yield is the same in both cases. To generalize, we assume that pulse 1 is of any form.

The amplitude of the rectangular pulse 2 (in Fig. 3) is equal to

\[
\psi(\tau - t_1)
\]

where

\[
\psi = \int_0^\tau \Phi(t) \, dt.
\]

It may easily be shown that

\[
\int_0^\tau \Phi(t) \, e^{\lambda t} \, dt < \int_{t_1}^\tau \frac{\psi}{\tau - t_1} \, e^{\lambda t} \, dt
\]

or, according to Eq. (1),

\[
a_1(\tau) < a_2(\tau).
\]