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REPORT TITLE: COMPARISON OF BERYLLIUM PHOTONEUTRON DECAY SETS USING EXPERIMENTAL SNAP REACTOR DATA

AUTHOR: E. H. Ottewitte

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STATEMENT OF PROBLEM

Compare beryllium photoneutron decay sets using experimental SNAP reactor data.

ABSTRACT

The Rotter " core " set was found to be particularly advantageous over the conventionally-used Keepin set.

COMPARISON OF BERYLLIUM PHOTONEUTRON DECAY SETS USING EXPERIMENTAL SNAP REACTOR DATA

The portion of photoneutrons which return to a subcritical SNAP reactor core from its beryllium reflector constitute its "unmultiplied" photoneutron source strength, N_o. Once they reach the core, these "first generation" photoneutrons are multiplied in successive generations by the reproduction factor k. In the absence of other neutron sources, the neutron population in a subcritical reactor converges then to

$$N_o\left(1 + \sum_{n=1}^{\infty} k^n\right) = \frac{N_o}{1-k}$$

The magnitude of N_o will depend on the time and power level of previous reactor operation (fission product buildup and magnitude) and on the time since shutdown (fission product decay). Knowing the unmultiplied photoneutron source strength and an associated set of suitable decay constants and yields, one can predict a given reactor's neutron population for all operating histories, time of shutdown, and degrees of subcriticality of interest.

Sets of photoneutron decay constants are extracted by analysis of careful experiments. Each set is therefore tuned to a particular reactor. Keepin has shown[1] his set to better fit available data than sets of earlier workers. No comparison was found for two later sets of Rotter[2].

The suitability of each set to a SNAP reactor was measured by its ability to fit the SNAP experimental data of interest. For comparison purposes, all available data were corrected with each set to the same N_o: at the time of shutdown from infinite operation at one thermal watt. The data spread, and/or the percentage deviation from the mean value

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$$\left\{ \frac{\sum_{i=1}^{N} \left[\frac{X_i}{\bar{X}}\right]^2 - N^2}{N-1} \right\}^{1/2}$$

indicate the set suitability.

Figure 1 compares set suitability for SNAP 8 data. The error bands reflect uncertainty in detector position. Additional uncertainty, not shown, is due to uncertainty in (1-k):

$$N_o = N_{measured} \quad (1-k)_{measured}$$

(As one approaches k=1, it becomes increasingly difficult to maintain the same number of significant figures.) Table 1 compares the data correlations above $({}^{1-k}/\beta) = 10¢$ (region of minimal (1-k) uncertainty). Both short and long term buildup and decay are represented. The Rotter "core" set is clearly more suitable here than the Keepin set.

The SNAP 10A data is a particularly strong test of the short-lived components. The Rotter sets again appear more suitable. The SNAP 2 data does not contain as much extreme short- and/or long-lived contributions. The Rotter sets offer only slight improvement in that correlation.

In summary, the Rotter "core" set is most suitable to analysis of SNAP reactor data. It appears particularly advantageous where extreme short- or long-lived contributions exist.

CORRELATION OF SNAP 8 EXPERIMENTAL PHOTONEUTRON DATA

DATA HAVE BEEN CORRECTED WITH THE INDICATED DECAY CONSTANTS TO THE CORE "UNMULTIPLIED" SOURCE STRENGTH AT THE TIME OF SHUTDOWN FROM SATURATED BUILDUP REACTOR OPERATION.

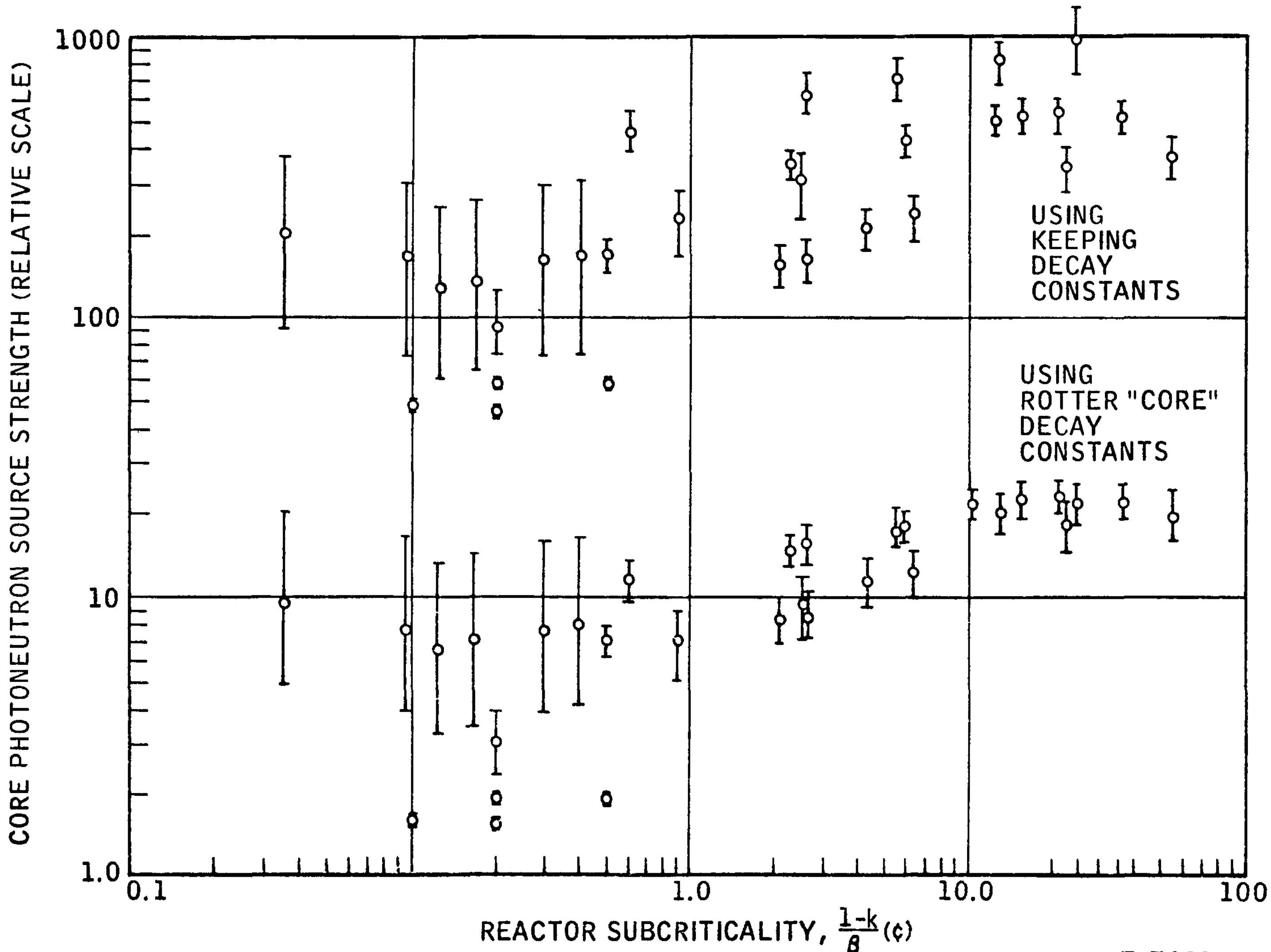

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Table 1. ANALYSIS OF SNAP DATA

Reactor	Prior Operation	Measurement Times, from Point of Shutdown	Number Data Points	% Deviation Keepin	% Deviation Rotter "core"	% Deviation Rotter "reflector"
SNAP 8 (data for $\frac{1-k}{\beta} > 10^4$)	up to 4500 hours at variable powers	4-234 hours	8	30.5	7.4	22.2
SNAP 10A	300 sec transient	1-20 hours	12	46.3	26.0	25.4
SNAP 2	600 hrs at constant power	12-100 hours	94	22.4	21.5	22.0

REFERENCES

1. G.R. Keepin, Nuclear Data for Reactor Kinetics, Nucleonics 20, No. 8, 150 (1962)

2. W. Rotter, Delayed Photoneutrons in the Beryllium Reactor BR 02, AI-TRANS-225. Translation of Nukleonik 5, 227 (1963) by E.H. Ottewitte (to be published)