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OTHER		AT(11-1)-GEN-8	PAGE 1 OF 5

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SUBJECT: Fast Neutron Flux Measurements for Shielding Applications

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I STATEMENT OF PROBLEM

To obtain fast neutron measurements using sulfur threshold detectors.

II SUMMARY OF RESULTS

Pressed sulfur pellets, irradiated in the L77 for two hours at 10 watts yielded satisfactory counting rates on an internal proportional counter for measuring fast neutrons. The pellets were counted in their original form and an equation applicable to thick sources was applied to obtain disintegration rates.

Decay data and beta energy analyses indicated that the induced activity was due to P^{32} .

Cross section values reported in the literature for the $S^{32} (n, p) P^{32}$ reaction involved were found to differ widely. The fast flux values given as an example in Table I are based on an assumed cross section of 285 millibarns(1) in a fission spectrum.

The results obtained are given in Table I and Graph I. Thermal flux values at the same positions and for the same power are also presented in the table and the graph. In the event that an experiment of this type is to be repeated, it is recommended that:

1. the radioactive phosphorus be chemically separated from the sulfur for absolute standardization,
2. additional information regarding higher neutron energies be obtained by observing the 2 1/2 hour Si^{31} activity [$S^{34}(n, \alpha) Si^{31}$] having a threshold energy of about 4.8 Mev.(2) Although the cross section is lower for this reaction, and the natural abundance of S^{34} is only ~4%, longer irradiation periods may yield some information.

TECHNICAL DATA RECORD

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III METHOD USED, DESCRIPTION OF EQUIPMENT, SAMPLE CALCULATIONS

The pellets used in this experiment were made of natural sulfur (flower of sulfur), pressed into discs. The average dimensions of the seven pellets used were as follows:

Weight = 3.042 ± .027 grams
Thickness = 0.635 cm
Diameter = 1.905 cm
Surface area = 2.85 cm²

Natural sulfur contains about 95% S³² and 4% S³⁴. The most predominant reaction is the S³² + n → P³² + p

However, S³⁴ also has a significant fast neutron reaction, (2)

The Si³¹ half life is 2.62 hours with a β decay energy of 1.5 Mev., similar to the P³² β energy of 1.7 Mev. To eliminate the Si³¹ component, the samples were permitted to decay for about one day prior to beta measurements.

The seven pellets were placed in known positions of the central glory hole of the L77 reactor and exposed to a two hour irradiation at 10 watts. None of the pellets were cadmium covered since it had been determined by a prior irradiation in the L77 that the cadmium ratio is about one.

After allowing sufficient time for the Si³¹ activity to decay, the pellets were counted in an internal flow type proportional counter. A ring of cadmium (1.7 grams/cm²) was fitted around the pellets so as to expose only the flat center surface to the detector. Several measurements were made over a three week period in order to observe the decay and thereby check on the purity of the sulfur pellets. A beta energy determination was also made. Both of these methods indicated that the only activity being observed was due to P³². Counts on both sides of the pellets agreed to within 3%.

The dimensions of these pellets are such that they constitute an "infinitely thick" sample for the β energy involved. The following equation (3) is applicable for relating counting rate to disintegrations occurring in the specimen and was used in calculating disintegrations per second from counts per second:

$$N_o = \frac{4N}{RA} \quad (1)$$

N = Counts per second per sample minus background, extrapolated to reactor out time.

N_o = Specific activity (dps/gm)

R = Range of the beta particles (assumed to be uniform for all particles) in gms/cm²

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A = Surface area (cm^2)

For example, substituting and solving for N_0 using pellet #1:

$R = 0.250 \text{ grams/cm}^2$, $A = 2.85 \text{ cm}^2$, $N = 89$

Then,

$N_0 = 500 \text{ dps/gm}$

The applicability of the above equation was experimentally verified by preparing thick samples, containing known amounts of standardized P^{32} which were counted on a 2 π counter. Values thus obtained agreed within 6% of those calculated by the above method.

In arriving at the fast flux values, a cross section of 285 millibarns⁽¹⁾ was assumed. For the $\text{S}^{32} (n, p) \text{P}^{32}$ reaction, the threshold energy (E_T) is about 1 Mev and the effective energy (E_{eff}) is about 3 Mev.

The equation used to obtain fast flux is as follows:

$$\phi_f = \frac{N_0 A}{N_{\text{av}} K \sigma (1 - e^{-\lambda t})} \quad (2)$$

where:

ϕ_f = neutron greater than 2.9 Mev/ cm^2/sec

N_0 = disintegrations/second/gram

A = atomic weight of sulfur

N_{av} = Avogadro's number

K = natural isotopic abundance

σ = cross section in barns

λ = decay constant

For pellet #1 where $N_0 = 500 \text{ dps/gm}$, $A = 32$, $N_{\text{av}} = 6.02 \times 10^{23}$, $K = 0.95$, $\sigma = .285 \times 10^{-24} \text{ cm}^2$ and $t = 2 \text{ hrs}$, we calculate from equation (2) that $\phi_f = 2.43 \times 10^7 \text{ n/s/cm}^2$.

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TABLE I

<u>Sample Number</u>	<u>Reactor Position Inches from C</u>	<u>N (C/S @ ot)</u>	<u>ϕ_f $E_{eff}=3\text{Mev}$</u>	<u>ϕ_{th} $n_o v$</u>
1	8"	89	2.43×10^7	9.01×10^7
2	5"	205	5.59×10^7	1.89×10^8
3	2½"	291	7.95×10^7	2.35×10^8
4	C	321	8.75×10^7	2.46×10^8
5	2½"	301	8.21×10^7	2.35×10^8
6	5"	234	6.38×10^7	1.89×10^8
7	8"	119	3.25×10^7	9.01×10^7

IV REFERENCES

1. Kleina - Hanson Physics Review 73, 106 (1948)
2. L. Allen, et al - Phys. Review 107, 1363 (1957)
3. J. Fresco, et al - Nucleonics 10, 8 Aug. 1952