UNCLASSIFIED

BNL-1992

Subject Category: PHYSICS

UNITED STATES ATOMIC ENERGY COMMISSION

THERMAL UTILIZATION MEASUREMENT

By
G. A. Price

August 19, 1954

Brookhaven National Laboratory
Upton, New York

Technical Information Service, Oak Ridge, Tennessee

UNCLASSIFIED

Date Declassified: November 9, 1955.

Issuance of this document does not constitute authority for declassification of classified material of the same or similar content and title by the same authors.

Printed in USA, Price 15 cents. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

GPO 988055

THERMAL UTILIZATION MEASUREMENT

By G. A. Price

An intra cell neutron flux traverse has been done in the BNL reactor by the Reactor Physics group, to measure thermal utilization. A special uranium fuel element was constructed with provision for containing 25 dysprosium foils internally and 12 dysprosium foils on the aluminum fins. The fuel element was 3 feet long and was constructed of the same materials which are normally used in the reactor fuel elements and was loaded into fuel channel A-9-6. A special graphite cartridge, 2.6" diameter and 2 feet long, was loaded into newsom hole A-9-6 1/2. Dysprosium foils were embedded in the graphite cartridge opposite the foils in the special fuel element. The distribution of dysprosium foils permitted a measurement of neutron flux in the uranium, on the aluminum fins, and in the graphite midway between nearest fuel rods. Figure I shows the relative positions of the dysprosium foils in the reactor.

Fifty-four dysprosium foils were exposed for 2 minutes at 40 kw pile power and were then counted in end window geiger counters. Each foil activity was corrected by its individual foil calibration factor, which had previously been determined, to give the relative neutron flux. An additional factor was applied to correct the flux distribution from the overall cosine flux distribution of a finite reactor to an overall flat flux distribution.

The thermal utilization f is calculated from the formula

$$f = \frac{N_u \sigma_u \bar{\phi}_u}{N_u \sigma_u \bar{\phi}_u + N_w \sigma_w \bar{\phi}_w + N_f \sigma_f \bar{\phi}_f + N_c \sigma_c \bar{\phi}_c}$$

N = atoms/cm^3

σ = neutron capture cross section at 2200 m/s

$\bar{\phi}$ = average neutron flux

u = uranium

w = aluminum tube wall

f = aluminum fins

c = graphite

In calculating average neutron fluxes cylindrical symmetry was assumed in the fuel rod and in the graphite out to the mid point between nearest fuel channels. The region between fuel channels which is not included in tangent circles circumscribed about adjacent channels is assumed to have a constant neutron flux.

The following table gives the parameters which were used in calculating thermal utilization.

Region	Density (gm/cm)	Density (gm/cm^3)	σ (barns)	$\bar{\phi}$*
Uranium	114.7	18.7	7.68 x 0.988**	1.2437
Aluminum wall	1.78	2.7	0.215	1.575
Aluminum fin	1.34	2.7	0.215	1.79
Graphite	636.79	1.69	0.0048	2.047

f = 0.890

* Neutron flux has been normalized to unity at the center of the uranium fuel element.

** The uranium absorption cross section has been corrected for the fact that it is not 1/v in the thermal region.

Figure II is a table of the observed dysprosium foil activities and corrections. Each foil was counted for more than 10,000 counts each in the end window geiger counters. Figure III is a graph of the relative intra cell neutron flux in the BNL reactor as measured with dysprosium foils.

The measured value of f = 0.890 is to be compared with the calculated value of f = 0.8964 which is given by I. Kaplan and J. Chernick in BNL 152.

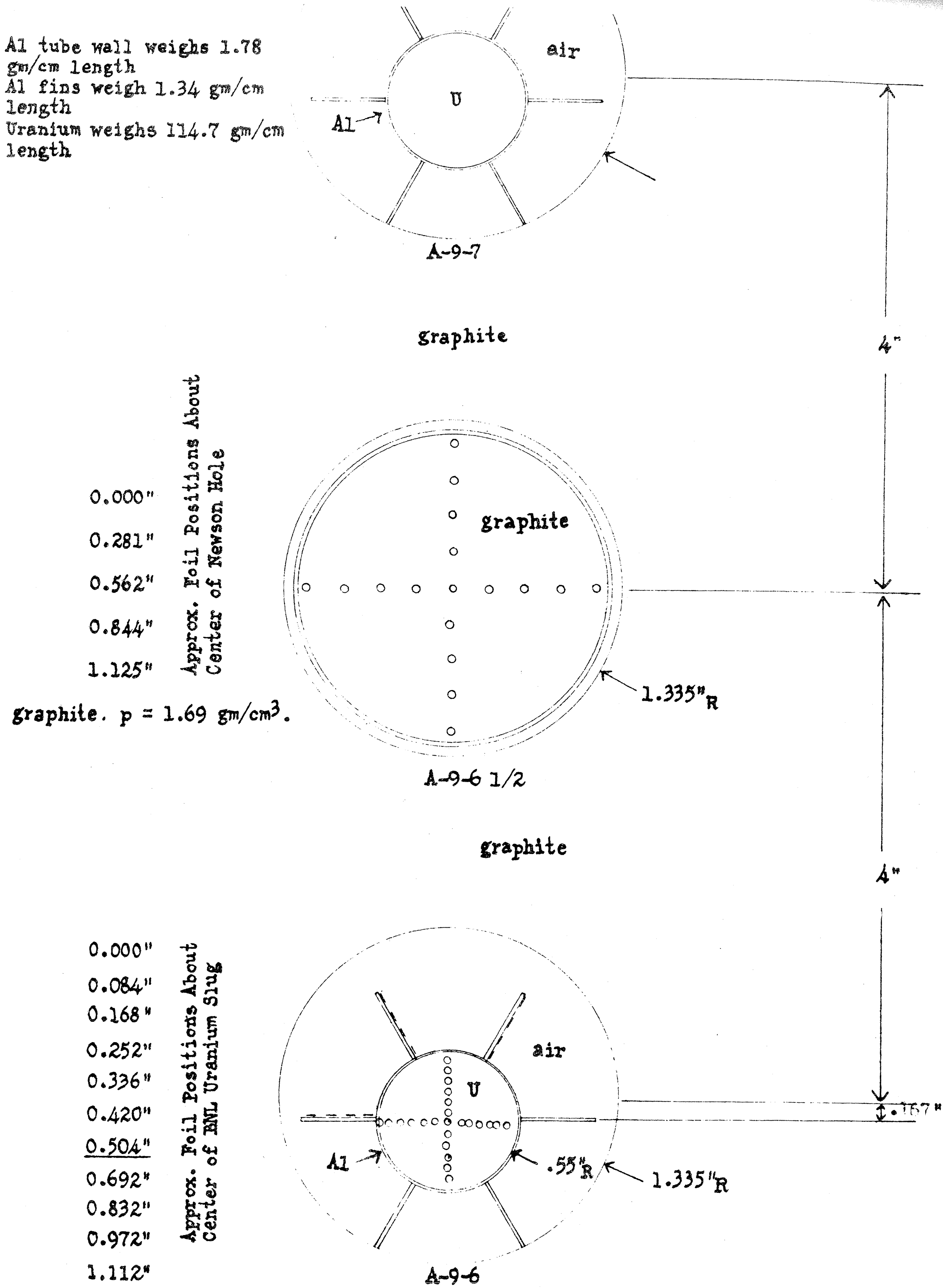
Al tube wall weighs 1.78 gm/cm length
Al fins weigh 1.34 gm/cm length
Uranium weighs 114.7 gm/cm length
air
U
Al
A-9-7
graphite
4"
Approx. Foil Positions About Center of Newson Hole
0.000"
0.281"
0.562"
0.844"
1.125"
graphite
1.335"R
graphite. p = 1.69 gm/cm3.
A-9-6 1/2
graphite
4"
Approx. Foil Positions About Center of BNL Uranium Slug
0.000"
0.084"
0.168"
0.252"
0.336"
0.420"
0.504"
0.692"
0.832"
0.972"
1.112"
air
U
Al
.55"R
1.335"R
A-9-6

Figure 1

Dysprosium Foil Position 1 x	2 y	3 r(inches) $\sqrt{x^2 \text{ x } y^2}$	4 Relative activity	5 Correction factor for cosine $\{1+.0165x\}\{1+.00889y\}$	6 Corrected relative neutron flux
0	5.011	5.011	1.9441	1.0445	2.0306
0	5.292	5.292	1.9657	1.0470	2.0581
0	3.886	3.886	2.0153	1.0345	2.0848
0	4.448	4.448	1.9530	1.0395	2.0301
0	4.167	4.167	1.9333	1.0370	2.0048
.281	4.167	4.177	1.9882	1.0418	2.0713
-.281	4.167	4.177	2.0455	1.0322	2.1114
.562	4.167	4.204	2.0041	1.0466	2.0975
-.562	4.167	4.204	2.1141	1.0274	2.1720
-.844	4.167	4.248	2.0022	1.0226	2.0474
-1.125	4.167	4.316	2.0009	1.0177	2.0363
0	3.323	3.323	2.0101	1.0295	2.0694
0	3.605	3.605	2.0034	1.0320	2.0675
.844	4.167	4.248	1.9808	1.0514	2.0826
0	3.042	3.042	1.9847	1.0270	2.0383
1.125	4.167	4.316	2.0383	1.0563	2.1531
0	4.729	4.729	1.9828	1.0420	2.0661
.346	.599	0.692	1.6856	1.0110	1.7041
.416	.721	0.832	1.7484	1.0133	1.7716
-.346	.599	-0.692	1.6815	.9996	1.6808
-.416	.721	-0.832	1.7597	.9995	1.7588
-.692	0	-0.692	1.7276	.9886	1.7079
-.556	.963	-1.112	1.7871	.9994	1.7860
-.486	.842	-.972	1.7551	.9995	1.7542
-1.112	0	-1.112	1.8892	.9817	1.8546
-.972	0	-0.972	1.8636	.9840	1.8338
-.832	0	-0.832	1.7985	.9863	1.7739
.252	0	0.252	1.1055	1.0042	1.1101
-.252	0	-0.252	1.0973	.9996	1.0969
.504	0	0.504	1.3909	1.0084	1.4026
.336	0	0.336	1.1436	1.0006	1.1443
-.336	0	-0.336	1.1717	.9945	1.1653
-.504	0	-0.504	1.4539	.9917	1.4418
0	-.336	-0.336	1.1329	.9970	1.1295
0	-.084	-0.084	1.0021	.9993	1.0014
-.084	0	-0.084	1.0842	.9986	1.0827
0	-.168	-0.168	1.0499	.9985	1.0483
0	.084	0.084	1.0123	1.0007	1.0130
0	.168	0.168	1.0358	1.0015	1.0374
0	0	0.000	1.0000	1.0000	1.0000

Figure 2

Figure 2 (Cont'd)

Dysprosium Foil Position 1	2	3	4	5	6
x	y	r(inches) $\sqrt{x^2 \text{ x } y^2}$	Relative activity	Correction factor for cosine $[1+.0165x]$ $[1+.00889y]$	Corrected relative neutron flux
0	-.504	-0.504	1.4767	.9955	1.4701
0	.420	0.420	1.2599	1.0037	1.2646
0	.336	0.336	1.1341	1.0030	1.1375
0	.252	0.252	1.0612	1.0022	1.0635
0	.504	0.504	1.4228	1.0045	1.4292
0	-.252	-0.252	1.1209	.9978	1.1184
-.168	0	-0.168	1.0576	.9972	1.0546
0	-.420	-0.420	1.2683	.9963	1.2636
.420	0	0.420	1.2482	1.0069	1.2568
.168	0	0.168	1.0381	1.0028	1.0410
.486	.842	0.972	1.8053	1.0156	1.8314
.556	.963	1.112	1.8099	1.0178	1.8421
-.420	0	-0.420	1.2662	.9931	1.2575
.084	0	0.084	----	1.0014	----

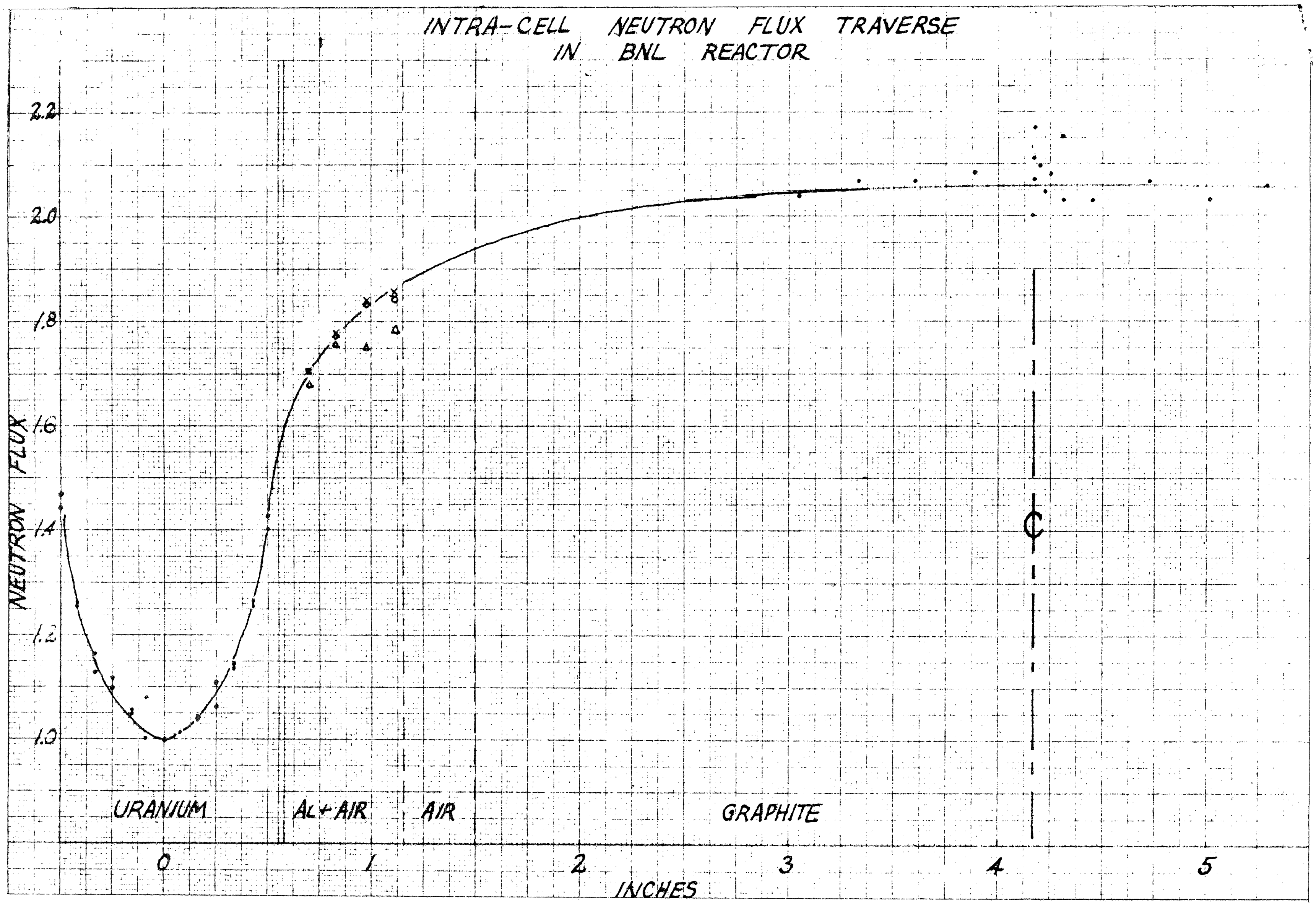
INTRA-CELL NEUTRON FLUX TRAVERSE
IN BNL REACTOR
NEUTRON FLUX
2.2
2.0
1.8
1.6
1.4
1.2
1.0
URANIUM
AL+AIR
AIR
GRAPHITE
℄
0
1
2
3
4
5
INCHES

Figure 3