BROOKHAVEN NATIONAL LABORATORY

M E M O R A N D U M

Date: December 7, 1959

To: Dr. J. S. Robertson

From: C. G. Amato CGA

Subject:

1.0 Recently, data have been analyzed which were taken, using various foils, with varying quantities of heavy water located between the BMRR core and the dose point (located at the center of the patient therapy portal). These data are presented in Table I. Table II contains a description of the shielding array. All measurements were taken at 1 megawatt. In addition, results of modifications in the liner of the cone are also reported.

2.0 Results of these measurements are summarized below.

2.1 No fast neutron flux, (energy greater than 2.9 MEV), was detected under any condition.

2.2 A fast neutron flux in the energy region 1.5 to 2.9 MEV is present. This flux is not a major component of the neutron spectrum. It is detected using boron-shielded fission foils (depleted U^{238}). Since the spectral distribution in this energy region is still unknown, I consider it unwise to convert a count rate to a number flux. However, relative intensity may be safely stated. As the amount of heavy water decreases, this component of the fast flux increases. When no heavy water is present, this component increases by a factor of 7.5 over the flux present with all D_2O tanks full.

2.3 The thermal neutron number flux and the gamma dose rate are inversely proportional to the amount of heavy water.

2.4 The average value for thermal flux with all heavy water tank full (as given by averaging data for six foils) is 5.1×10^{10} n/cm$^2\cdot$ sec. This increases to 6.5×10^{10} n/cm$^2\cdot$ sec when all D_2O tanks are empty.

2.5 The gamma dose rate, as measured with a Li shielded Victoreen condensor-r-meter, rises from 400 r/min when all heavy water tanks are full to 541 r/min when all tanks are empty.

2.6 Application of the cadmium difference method results in a correction in the second or third decimal place of the coefficient. Data taken by Dr. Stickley and J. Gilmartin using bare foils is, therefore, under these conditions, an accurate measure of thermal flux.

2.7 The gold and cobalt resonance flux values (5 and 120 ev, respectively) are 10^2 times lower than the thermal flux.

3.0 Structural modifications are still in progress. Measurements will be made after each revision. Flux determinations will shortly be begun at the old medical facility atop the graphite pile. In-vivo measurements will be made at the BMRR as soon as structural revisions cease.

4.0 The following revisions were made under the direction of R. W. Powell (measurements were taken by J. Gilmartin).

4.1 The plastic reflector and outer Bi block were removed.

$$\phi_{TH} = 1.89 \times 10^{10} \text{ n/cm}^2\text{-sec.}$$

$$\phi_{\gamma} = 180 \text{ r/min}$$

4.2 The polyethylene liner was inserted.

$$\phi_{TH} = 7.45 \times 10^{10} \text{ n/cm}^2\text{-sec.}$$

$$\phi_{\gamma} = 81.8 \text{ r/min}$$

4.3 8" of Bi were removed from the inner block and the plastic reflector taken out.

$$\phi_{TH} = 3.82 \times 10^{10} \text{ n/cm}^2\text{-sec}$$

$$\phi_{\gamma} = 750 \text{ r/min}$$

4.4 The plastic reflector was inserted.

$$\phi_{TH} = 6.4 \times 10^{10} \text{ n/cm}^2\text{-sec}$$

$$\phi_{\gamma} = 800 \text{ r/min}$$

4.5 A 1/4" thick aluminum sheet was placed over all surfaces of the liner.

$$\phi_{TH} = 6.12 \times 10^{10} \text{ n/cm}^2\text{-sec}$$

$$\phi_{\gamma} = 857 \text{ r/min}$$

4.6 The plastic liner and aluminum sheet were removed. The concrete cone surface was covered with a 2.5-inch layer of Bi.

$$\phi_{TH} = 5.24 \times 10^{10} \text{ n/cm}^2\text{-sec}$$

$$\phi_{\gamma} = 550 \text{ r/min}$$

4.7 A boron carbide epoxy resin plate was placed between the dose point and core with the arrangement noted in 4.5.

ϕ_{TH} = not measured

$$\phi_{\gamma} = 670 \text{ r/min}$$

4.8 The core to dose point material sequence was altered and is described under "new configuration" in Table II. The Bi liner has been retained.

$$\phi_{TH} = 1.66 \times 10^{10} \text{ n/cm}^2\text{-sec}$$

$$\phi_{\gamma} = 54 \text{ r/min}$$

4.9 The preceding measurements were made at or scaled to 1 megawatt. All heavy water tanks were full at all times. Knowledge of core configuration by the reader of this memo is assumed.

5.0 An automatic wire scanner is under construction. A slow chopper will be received sometime in late January (sic). Gamma dose and spectral measurements will be soon begun. A subsequent memo will contain a critique of the foil technique.

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TABLE 1

MEASUREMENT CONDITION AND

Type of Foil	All D_2O Tank Full				Two D_2O Tank Full			
	ϕ_{TH+RES}	ϕ_{RES}	ϕ_{TH}	CR	ϕ_{TH+RES}	ϕ_{RES}	ϕ_{TH}	CR
Lead gold alloy	4.11×10^{10}	2.77×10^{8}	4.08×10^{10}	7.9	4.71×10^{10}	3.79×10^{8}	4.67×10^{10}	6.6
Gold leaf	5.1×10^{10}	2.77×10^{8}	5.05×10^{10}	9.8	6.59×10^{10}	3.4×10^{8}	6.6×10^{10}	10.4
Gold disk (0.5 mil)	5.31×10^{10}	1.5×10^{9}	5.16×10^{10}	18.6	5.39×10^{10}	2.43×10^{8}	5.91×10^{10}	13.
Gold disk(1/8" O.D.)	6.39×10^{10}	1.04×10^{8}	6.38×10^{10}	33.	5.28×10^{10}	1.6×10^{8}	5.26×10^{10}	18.
Gold pellet	4.79×10^{10}	7.76×10^{7}	4.79×10^{10}	34.	4.85×10^{10}	1.12×10^{8}	4.85×10^{10}	23.
Co disk	5.056×10^{10}	2.19×10^{8}	5.03×10^{10}	149.	5.1×10^{10}	3.4×10^{8}	5.07×10^{10}	96.
Gamma dose rate		24,000 r/hr				25,680 r/hr		

All flux values are number flux having the dimension n/cm^2-sec.

All flux measurements were taken at 1 megawatt.

ϕ_{TH+RES} is the thermal plus resonance flux as measured with a bare foil.

ϕ_{RES} is the resonance flux above the cadmium cutoff of 0.4 ev as measured with a cadmium-covered foil.

ϕ_{TH} is the thermal flux (less than 0.17 ev). It is the difference between ϕ_{TH+RES} and ϕ_{RES}.

CR is the cadmium ratio per unit weight of a set of foils.

TYPE OF MEASUREMENT

One D_2O Tank Full				No D_2O Tank Full			
ϕ_{TH+RES}	ϕ_{RES}	ϕ_{TH}	CR	ϕ_{TH+RES}	ϕ_{RES}	ϕ_{TH}	CR
5.25×10^{10}	4.43×10^{8}	5.48×10^{10}	6.5	5.95×10^{10}	5.79×10^{8}	5.89×10^{10}	5.5
6.8×10^{10}	5.6×10^{8}	6.7×10^{10}	6.5	7.5×10^{10}	6.8×10^{8}	7.5×10^{10}	6.0
6.5×10^{10}	3.18×10^{8}	6.43×10^{10}	11.	6.76×10^{10}	4×10^{8}	6.72×10^{10}	9.0
6.27×10^{10}	2.58×10^{8}	6.24×10^{10}	13.	6.53×10^{10}	3.1×10^{8}	6.5×10^{10}	11.
6.15×10^{10}	1.79×10^{8}	6.13×10^{10}	18.	5.9×10^{10}	2.38×10^{8}	5.87×10^{10}	14.
5.87×10^{10}	5.32×10^{8}	5.8×10^{10}	73.	6.55×10^{10}	7.38×10^{8}	6.48×10^{10}	58.
28,920 r/hr				32,500 r/hr			

TABLE II

Sequence of Shielding Materials

Patient Therapy Portal

Old	New
Core	Core
2.5 in. graphite	2.5 in. graphite
0.25 in. Al	0.25 in. Al
0.25 in. air gap	0.25 in. air gap
8.0 in. graphite	8.0 in. graphite
12 in. Bi	12 in. Bi
5.5 in. D_2O	5.5 in. D_2O
0.25 in. Al	0.25 in. Al
0.12 in. Mg	0.12 in. Mg
4.0 in. graphite	4.0 in. air gap
8.0 in. Bi	8.0 in. Bi
17 in. air gap	17.0 in. air gap
dose point	2.0 in. Bi dose point
plastic reflector	Bi reflector