Chapter 5 Appendix 4

RADIOCHEMICAL ESTIMATION OF NEUTRON FLUENCE OF HIROSHIMA AND NAGASAKI ATOMIC BOMBS

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Purpose: To estimate neutron fluence of Hiroshima and Nagasaki atomic bombs by radiochemical methods.

Methods: Thermal neutron fluence at the time of explosion was estimated from the results of radiochemical analysis of residual ^{60}Co in iron materials or iron products.

Results: Materials were obtained through the kindness of Dr. Masanori Nakaidzum. In the present experiment water troughs of the A-Bomb Dome, which was directly below the burst point, were used as Hiroshima material and iron rods from the roof of the one-storied concrete building of Nagasaki Medical College (now the Nagasaki University School of Medicine) as Nagasaki material. Rust and extraneous matter were removed from the surface of these materials with hydrochloric acid, and the materials were washed with pure water and alcohol and dried to prepare the samples for analysis. Colorimetry of cobalt for part of the samples was performed by nitroso R salt method, and the other part was used as samples for ^{60}Co determination. The ^{60}Co samples were dissolved in hydrochloric acid and iron II was oxidized to iron III with nitric acid. Then, a fixed amount of cobalt carrier was added to separated iron. Cobalt was precipitated with α-nitroso-β-naphthol and then transformed to cobalt oxide by intense heat after which it was placed in a counter plate to count beta rays. Radioactivity was determined using a low background counter (ALOKA LBC-1).

Since that which was counted was considered to be ^{60}Co, it was precipitated together with a fixed amount of cobalt carrier using a predetermined amount of ^{60}Co standard solution whose decay rate was known. The counting efficiency was thus determined in the same geometry used for counting samples. The activity of the ^{60}Co in curies per gram of cobalt

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Table 1. Radiochemical Measurements of ^{60}Co and Estimation of Thermal Neutron Fluence

Material number	Nature of material	Amount of material collected (g)	Amount of cobalt in material (ug)	Cobalt added carrier (mg)	Amount of cobalt and carrier in material (mg)	Recovery rate of cobalt for determination (%)	Count of cobalt (cpm)	Corrected count efficiency rate (dpm)	Corrected chemical recovery rate (dpm)	dps per gram cobalt	Thermal neutron fluence (cm^{-2})
1	Water troughs, Hiroshima A-Bomb Dose	5.331	815	10.5	11.3	81.2	7.0±0.5	21.7±1.6	26.7±1.9	544.8±38.0	$2.5^{7}_{7}\pm8.18\times10^{12}$
1′	"	16.251	2486	10.5	13.0	47.7	12.8±0.2	39.7±0.6	83.1±1.3	557.4±8.7	$2.6_{2}\pm0.06\times10^{12}$
2	Iron rods, roof of Nagasaki Medical College	7.100	1341	10.5	11.8	56.1	0.7±0.3	2.2±0.9	3.7±1.6	46.3±19.0	$2.2\ \pm0.9\ \times10^{12}$
2′	"	16.113	3047	10.5	13.6	56.8	2.0±0.3	6.2±0.9	10.9±1.6	59.3±19.0	$2.8\ \pm0.4\ \times10^{12}$

Background of ALOKA LBC-1 (including stainless steel plate) was 0.8±0.02 cpm.
Radioactivity of cobalt carrier was 0.0 cpm.

was obtained by correcting for counting efficiency, chemical recovery rate, and ^{60}Co decay from August 1945, to Septemeber, 1960 (the time of determination). The thermal neutron fluence at the samples was estimated from their activity. The results are shown in Table 1.

The material subjected to counting was assumed to be ^{60}Co because the radioactivity content of the precipitated cobalt (per unit weight) was in accord, within the range of experimental error, even when the amount of sample was changed. Further review will be made of this point in the future. It is estimated from the results of this experiment that the Hiroshima materials received 2.6×10^{12} cm^{-2} of thermal neutron fluence and the Nagasaki materials received 2.5×10 cm^{-2}. Fast neutron fluence cannot be determined. In the interpretation of these results, the distance from the burst point and the degree of shielding of the materials should be taken into consideration. The neutron fluence of the Nagasaki bomb is considered to be lower than that of the Hiroshima bomb, but comparison of the materials of Hiroshima and Nagasaki should be made by taking into account the above mentioned factors. The distribution of neutron fluence in Hiroshima and Nagasaki can be determined by measuring the residual radioactivity of many pieces of material by such radiochemical methods.

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