Chapter 5 Appendix 9

ESTIMATION OF EXPOSURE DOSE

Eizo Tajima
St. Paul's University; Nuclear Safety Commission

Noboru Oda
Tokyo Institute of Technology

The purpose of these studies is to elucidate the qualitative and quantitative relationship between various causative factors of A- and H-bomb disturbances and effects on man, and from the finding, it is felt it should be possible to shed light upon the state of A-bomb sequela as well as the epidemiological and genetic effects on the survivors, and provide basic data for study of effects of radioactive fallout on man.

Estimation of Exposure Dose

Determination of the primary neutron and the primary gamma-ray doses from the Hiroshima A-bomb at various locations on the ground is not only important in itself, but also is of significance as a basis for estimating residual radiation. As no measured primary gamma dose is available, it was necessary to estimate the amount of fission (A-bomb) uranium at that time from the actually measured induced radiation based on fast and slow neutrons, and from this, estimate the prompt (primary) gamma-ray dose.

First, for fast neutrons, the measured values of radioactive phosphorus due to the sulfur S(n,p)P reaction in insulators of electric power poles as reported by Yamasaki and Sugimoto[1] and Sugimoto[2] can be used. As this reaction is approximately 2.5 MeV in effective threshold energy, it is considered that the attenuation of fast neutrons in air can be comparatively well approximated by the effective removal cross-section method. The number of fast neutrons are sought at the center of the bomb by i) assuming that the energy spectrum of neutrons does not change by transmission through air, ii) giving consideration to the neutron energy dependence of the S(n,p)P reaction cross section, iii) estimating the insulator transmission factor to be 0.8, and iv) using the number of disintegration per second of radioactive phosphorus in 1 g of sulfur as a function of distance from the hypocenter that is given in the report by Sugimoto,[2] and as the result obtained a rough value of 4×10^{21}. This is equivalent to approximately 0.6 g of fission uranium.

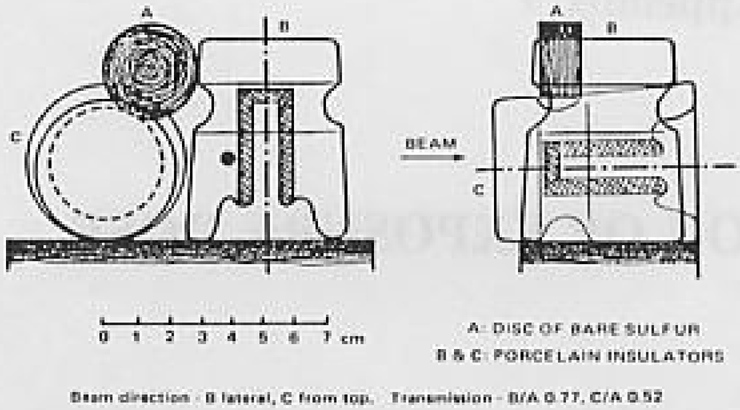

Figure 1. Arrangement of utility pole insulators and sulfur for irradiation

Table 1. Measured Values of Neutron Absorption in Utility-pole Insulators

Samples (sulfur)	Transmission coefficient
B (lateral irradiation)	(B/A) 0.77
C (irradiation from above)	(C/A) 0.52

Next, using the measured values by Yamasaki et al[3] for radioactive phosphorus induced by slow neutrons, the following two calculations were made: i) When the diffusion equation is simplified by assuming that all of the slow neutrons on the ground were generated in the center of the bomb, the weight of fission uranium is approximately 40 kg.

Next, ii) contrary to i) above, when it is assumed that the slow neutrons on the ground are fast neutrons that were released from the center of the bomb with an original energy of approximately 2 MeV, but became slow neutrons after being slowed down by scattering in air, and the slowing down and attenuation of neutrons are approximated by the two-group theory, there was a great discrepancy in the number of primary neutrons at the bomb's center as estimated from the intensity of radioactive phosphorus located at various locations. In light of the above, it appears that estimation of the amount of fission uranium is difficult by using slow neutrons and that using actual determinations of fast neutrons is more accurate.

Therefore, in order to determine experimentally the previously assumed fast neutrons transmission factor of insulators, we used as the radiation source neutrons generated through the D-D reaction by a Cockroft accelerator at Rikkyo University and neutrons obtained by Be-D reaction generted by the physical and Chemical Research Institute (Rikeo) cyclotron. The insulators and sulfur were arranged as shown in Figure 1 and irradiated, after which the beta rays of phosphorus generated were measured with a GM counter. The results are shown in Table 1. A is the mean for sulfur placed outside of the insulator, and B and C are for sulfur inside the insulators. Especially in C, there was a considerable discrepancy in the amount of radioactive phosphorus along the axis of incidence of the neutrons.

Further, exposed persons in Hiroshima were selected from the Red Cross Hospital medical charts whose location at the time of the bomb and subsequent activity were relatively easy to analyze, and are at present attempting to estimate their exposure doses. Also the residual radiation which is necessary for this also being studied.

References

1. Yamasaki, R. and Sugimoto, A., 1953. Radioactive ^{32}P in sulfur in Hiroshima. In *Collection of Investigative Reports on Atomic Bomb Disaster*, vol. 1, p. 18. Tokyo: Japanese Science Promotion Society.
2. Sugimoto, A., 1953. In *Collection of Investigative Reports on Atomic Bomb Disaster*, vol. 1, p. 19. Tokyo: Japanese Science Promotion Society.
3. Yamasaki, F., Sugimoto, A., and Kimura, M., 1953. In *Collection of Investigative Reports on Atomic Bomb Disaster*, vol. 1, p. 16. Tokyo: Japanese Science Promotion Society.