Chapter 5 Appendix 5

DATA ON NEUTRONS IN HIROSHIMA

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Study of A-bomb radiation dosimetry began with collection of exposed samples for studying neutrons and gamma rays in Hiroshima.[1]

For neutrons, dosimetric information is found in the radioactivities of ^{60}Co and ^{152}Eu. These radioactivities, among those produced by neutrons from the A-bomb, have remained to date and can be relatively easily measured. They are found in iron and granite materials and are produced almost entirely by thermal neutrons (0.025 eV) and by slow neutrons (0 to 1 keV) containing thermal neutrons.

According to an ICRP report,[2] the effect of neutrons on the human body varies widely with energy and is most important between 0.01 and 1 Mev; the effect per fluence in the lower part of this energy range is small, 1/30 to 1/40 of that in the higher part. The neutrons in A-bomb radiation have a continuous energy spectrum up to several MeV. Therefore, study of the production of ^{60}Co and ^{152}Eu does not permit making a direct estimation of the fast neutrons (0.5 to 10 MeV), among the neutrons from the A-bomb, that affect the human body. The radioactivities produced by neutrons, however, change with depth in the material they penetrate. Thermal neutrons are absorbed close to the surface. High energy neutrons penetrate much deeper; while doing so, they slow down to thermal energies at which they produce their radioactivity. Therefore, it can be said that the depth distributions of ^{60}Co/Co and ^{152}Eu/Eu in the materials include information about the energy spectrum of the incident neutrons.

Of the materials exposed to neutrons, those at three points will be discussed here: iron materials of the former Sumitomo Bank located at about 250 m south-east of the hypocenter,[3,4] iron and granite materials of the former Fukoku Life Insurance Building about 300 m south-east of the hypocenter, and iron and granite materials from the former Aioi Bridge about 300 m north-west of the hypocenter.[5,6] Figure 1 shows the ground plan of the former Aioi Bridge. Most of the above exposed materials were unshielded and were located directly facing the epicenter. However, some samples which had been shielded by concrete and others were used to study shielding effects.

Figures 2 and 3 show the specific radioactivities of ^{60}Co and ^{152}Eu on the surface of the

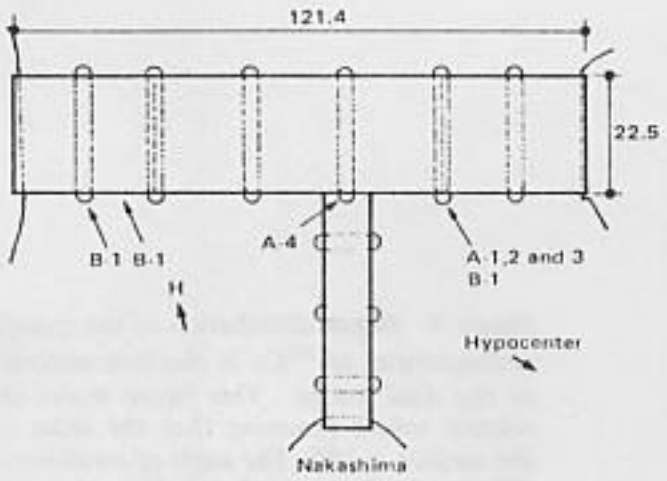

Figure 1. Plan for the Aioi Bridge. Lengths are shown in meters. A-1 to A-3 and B-1 to B-3 show the places where the materials were collected.[5,6]

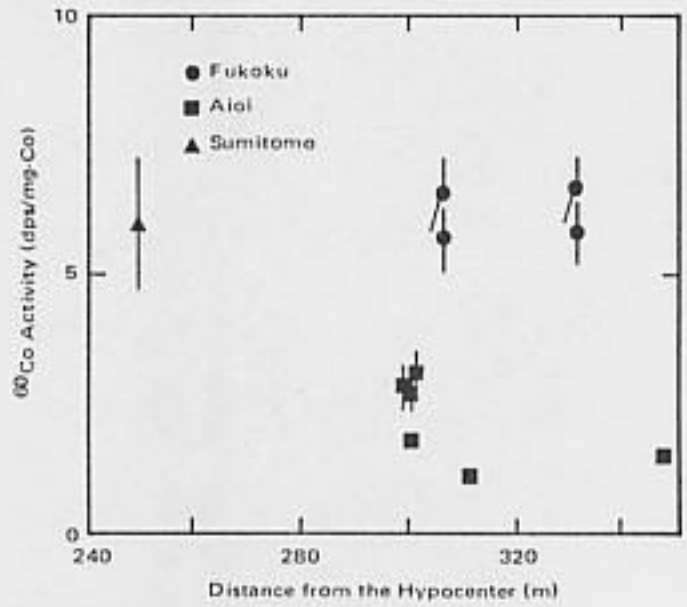

Figure 2. Results of measurement of specific radioactivities of ^{60}Co in iron.[3,5,6]

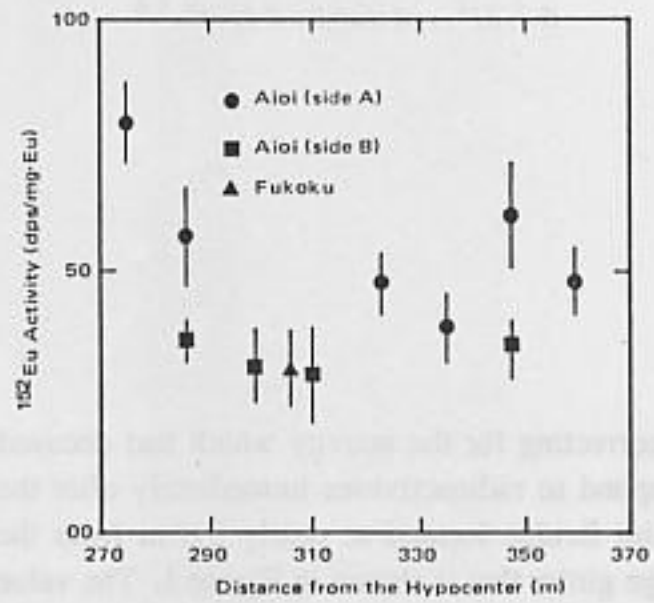

Figure 3. Results of measurement of specific radioactivities of ^{152}Eu in granite samples.[5,6] *Side A was collected from the side of bridge pier and Side B from the upper part of the pier*

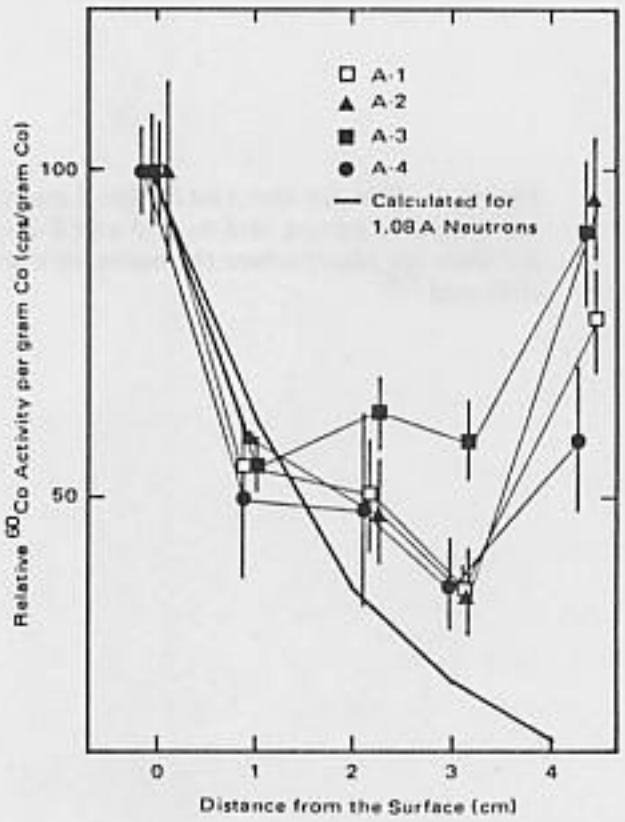

Figure 4. Depth distribution of the specific radioactivities of ^{60}Co in the iron materials of the Aioi Bridge. This figure shows the relative values assuming that the value on the surface is 100. The angle of incidence is 79° for the A-group of the places shown in Figure 1,5,6

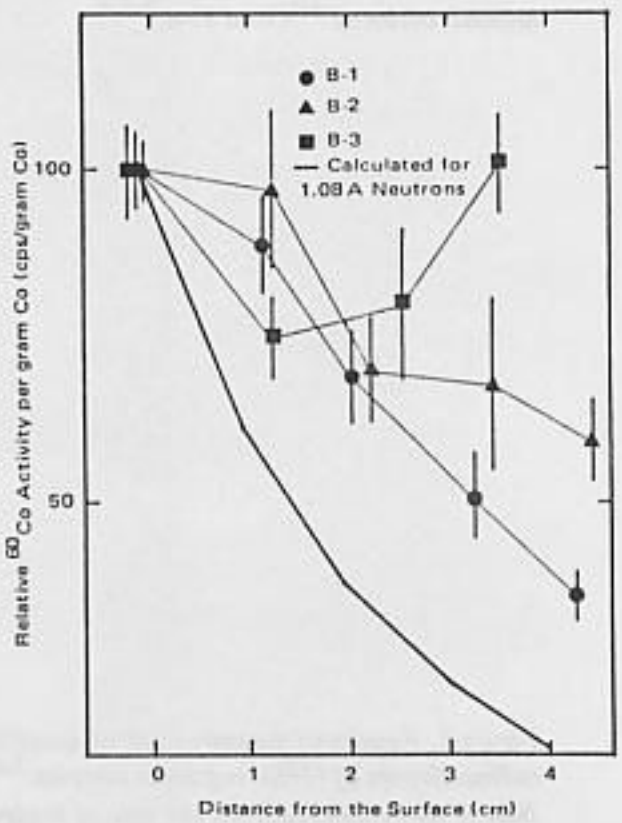

Figure 5. Depth distribution of the specific radioactivities of ^{60}Co in the iron of the Aioi Bridge. This figure shows relative values assuming the value at the surface is 100. The B-group are the places shown in Figure 1. Angle of incidence for B-1 is 26°; that for B-2, 31°; and that for B-3, 30°.[5,6]

materials. As these values were obtained by correcting for the activity which had decayed with lapse of time after exposure, they correspond to radioactivities immediately after the explosion of the bombs. The data for the Aioi Bridge located at nearly 310 m from the hypocenter were collected from under the bridge girder that is shown in Figure 1. The value

of $^{60}Co/Co$ in the iron material at this point was approximately one half of those at other points. On the other hand, the value of $^{152}Eu/Eu$ on the surface of the bridge pier was close to that of other pier stones. The $^{152}Eu/Eu$ measurements for pier granites differ between the upper part and the side of the bridge pier. This seems attributable to the effects of river water and to the shape and direction of the surface of the stones. Values for the iron materials on the roof of the former Fukoku Life Insurance Building were almost the same as those for the former Sumitomo Bank Building. Difference in distance from the hypocenter betwen the two was approximately 50 m.

Next, the depth distribution in the samples was obtained. First of all, distribution of ^{60}Co specific radioactivities in the iron materials of the Aioi Bridge was estiamted. Thicknesses of these iron materials totaled 5 cm. Five pieces each 1 cm in thickness were measured with a Ge detectoar. Figure 4 shows the results obtained from the iron which had been placed vertically on the bridge pier and Figure 5 shows those from the iron placed horizontally on the pier. "Angle of incidence" means the the angle formed by a line from the epicenter to the surface of the material and a line perpendicular to the surface of the material. The values marked with T are those calculated assuming that only thermal neutrons entered the surface of the materials. In Figure 4, the values for the point at 4 cm from the surface are larger than those at smaller depths. This increase was probably due to the incidence of neutrons from the rear side.

Types, characteristics, and problems of the data on neutrons have been described so far, and these are all related to specific activities as the basic quantity. It is necessary to study further the significance of the data for evaluation of neutron spectrum and dose, and to review to what extent these can be analyzed during the evaluation process.

References

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