Determination of $^{60}\text{Co}$ Activity in Steel Samples in Hiroshima

TATSUJI HAMADA

Japan Radioisotope Association,
2-28-45 Honkomagome, Bunkyo-ku, Tokyo 113, Japan

Atomic bomb/Neutron induced activity/$^{60}\text{Co}/Steel/Gamma-ray spectrometry

Specific activity of $^{60}\text{Co}$ in two steel samples taken at 687m S and 1295m NNW from the hypocenter was measured by gamma-ray spectrometry and neutron activation analysis\(^1\). The results are consistent with previous data by Hashizume et al. for steel rings on the surface of roofs of buildings. Content of nickel and copper in the samples was found to be too small to account for any significant $^{60}\text{Co}$ production by fast neutron reactions.

INTRODUCTION

When the new dosimetry system, DS 86, has been approved, it was known that measurements of $^{60}\text{Co}$ activities made by Hashizume et al.\(^2\) in the 1960s showed a slower decrease of thermal neutron fluence with distance than used in DS 86.

According to the recommendation of the Senior Dosimetry Committees of the US and Japan, further measurements of $^{60}\text{Co}$ activity have been made to see if the earlier results could be confirmed.

MATERIALS AND METHODS

Among five categories of steel materials reserved by RERF, two (No. 1 and No. 3) were selected. Sample No. 1 is a steel rod taken from the handrail of the stand at the top of the smokestack, about 25m above ground, of the Chugoku Electric Company Building in Hiroshima (U.S. Army Map, 44.38 x 60.96), 687m S from the hypocenter.

Sample No. 3 was taken from a section of the steel beam cut from the top of the arch of Yokogawa Bridge in Hiroshima (U.S. Army Map, 43.88 x 63.06), 1295m NNW from the hypocenter. This sample consisted of three steel plates and a steel angle riveted together. They were separated and the uppermost plate directly exposed to the bomb was subjected to further processing. The sample is estimated to have been 14.8m above water level at the time of bombing and 10.7m above ground.
Both samples were cleaned and cut into pieces to facilitate dissolving in HCl. The amounts prepared were 204.1g and 1553.2g, respectively. Most of the iron, converted to Fe$^{3+}$ by HNO$_3$, was removed by the zinc oxide method and succeeding purification of cobalt was accomplished by an anion exchange method. The recovery of cobalt was more than 80%. The eluate containing the cobalt was transferred to a small vessel, evaporated to dryness and subjected to gamma-ray spectrometry. For Sample No. 3, the significant result was obtained by counting for 500 hrs using a well-type germanium detector of higher counting efficiency. Stable cobalt content of the steel samples was determined by neutron activation analysis.

$^{60}$Co and stable cobalt which might have been contained in the reagents used in the process of chemical separation were determined and both were found to be negligible.

Copper and nickel content in the steel samples were determined by neutron activation and colorimetric analyses, respectively, because these elements would have yielded $^{60}$Co by fast neutron reactions$^3)$. The results shown in Table 1 indicate that the contribution of copper and nickel to $^{60}$Co production can be neglected.

**RESULTS**

The results of $^{60}$Co determination in the steel samples in terms of specific activity at the time of bombing (ATB) are shown in Table 2 together with the data by G.D. Kerr et al.$^4)$ for duplicate samples. The bridge samples measured by Kerr et al. were a steel plate facing the river as opposite to ours.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Nickel (mg/g)</th>
<th>Copper (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>$(3.11 \pm 0.03) \times 10^{-1}$</td>
<td>$1.25 \pm 0.04$</td>
</tr>
<tr>
<td>No. 3</td>
<td>$(2.47 \pm 0.04) \times 10^{-1}$</td>
<td>$3.0 \pm 0.1$</td>
</tr>
</tbody>
</table>

Table 1. Content of nickel and copper in steel samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>stable cobalt (mg/kg)</th>
<th>specific activity (dpm/mg Co, ATB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>This work</td>
</tr>
<tr>
<td>No. 1</td>
<td>$(1.11 \pm 0.03) \times 10^2$</td>
<td>$(2.64 \pm 0.38) \times 10^1$</td>
</tr>
<tr>
<td>No. 3</td>
<td>$(1.90 \pm 0.06) \times 10^2$</td>
<td>$(3.09 \pm 0.48) \times 10^{-1}$</td>
</tr>
</tbody>
</table>

Table 2. Specific activities of $^{60}$Co in steel samples
Fig. 1. Measured and calculated data of specific activity of $^{60}$Co at the time of bombing, induced in steel by bomb neutrons in Hiroshima.

Error bars for the data points of this work express statistical error of counts, while those for the steel bar data of Hashizume et al. are ranges of 9 measurements for each sample. Samples of this work and the steel rings were directly exposed to the source. The steel bars were at a depth of 8cm in concrete, for which Loewe's calculation was made.
DISCUSSION

In Figure 1 the data of this work are plotted as a function of ground distance, together with those of Hashizume et al. who measured $^{60}$Co activity of steel bars embedded at a depth of 8 cm in concrete and that of steel rings directly exposed to the bomb on roofs of buildings. The present data are consistent with the data for steel rings. The solid line is the result of calculation by W.E. Loewe\textsuperscript{3}), which should be compared with the steel bar data.

The data of this work, though not directly comparable with the calculated data, would appear to support the observation that the measured data tend to be greater than the calculated data at greater distances.

REFERENCES


