Chapter 2 Appendix 1

POWER CALIBRATION OF THE HIROSHIMA BOMB REPLICA

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In making measurements at the Hiroshima Bomb Replica, investigators were given the power level at the time of their measurement. They converted this level into the fission rate within the reactor with a calibration factor.

The primary power measuring device was a polyethylene covered BF_3 ionization chamber (Westinghouse WL-6937A) mounted on the stand holding the replica. The current from the chamber was fed to a linear, digital current integrator. Other BF_3 ionization chambers were mounted inside the reactor building and were available for use when the replica was used inside. Several different methods of determining the fission-rate calibration factor were used:

Absolute counting of uranium foils that had been placed on top of the core of the replica. The foils were 0.5 inch diameter and 0.001 inch thick and were wrapped in aluminum. ^{99}Mo was determined radiochemically. ^{91}Sr, ^{97}Zr, ^{99}Mo, ^{103}Ru, and ^{140}Ba were determined by absolute counting with a high-purity germanium gamma-ray counter.

Comparative counting with a deep-well NaI scintillation counter of uranium foils exposed in the replica and in a burst of neutrons from the calibrated Godiva reactor at Los Alamos.

Feynman variance-to-mean measurements.

Calibration runs were made on 6 November 1982 with the replica inside the building and on 12 April 1983 with it outside. The calibration factor, in fissions per count of the digital current integrator, was 6.18×10^9 after the 1982 calibration.

The various estimates of power calibration, however, were not in good agreement. A final calibration run was made on 6 August 1984 using aluminum-wrapped uranium foils on top of the core and radiochemical determination of ^{99}Mo. This run showed the seriousness of fission product escape from the thin foils used in the first two runs. The escape correction was estimated taking into account the presence of the oxide layer on the surface of the

Table 1. Reactor Power Calibration Coefficients

Date	Reactor Location	old[a] Calibration Coefficient	New[b] Calibration Coefficient		Correction Factor
21 Sept 82-16 Dec 82	in Kiva II	$6.35 \cdot 10^{-8}$c	$5.09 \cdot 10^{-8}$		.802
12 Apr 83-31 May 83	outside	$6.18 \cdot 10^{9}$d	$7.53 \cdot 10^{9}$e	0.048t e	f
18 July 83-10 Apr 84	in Kiva II	$6.18 \cdot 10^{9}$d	$7.51 \cdot 10^{9}$e	0.048t e	f
7 May 84-13 Aug 84	outside	$6.18 \cdot 10^{9}$d	$7.53 \cdot 10^{9}$e	0.048t e	f

a) Used by experimenters in data reduction examined in this report.

b) Revised power calibration.[1]

c) "ϵ_3" value of digital integrator counts/fission.

d) Fissions/digital current integrator counts on the 10^{-6} range.

e) t in years after 12 Apr 83.

f) Depends on date of measurement.

Table 2. Reactor Power Correction Factors for Measured Fluences

Measurement	Dates	Reactor Location	Correction Factor
Robitaille	Sept – Oct 82	Inside	.802
Griffith	25-29 Apr 83	Outside	.819
Evans 1	3-24 May 83	Outside	.817
Verbinski 1	26 July 83	Inside	.820
Gold 1	16-19 Sept 83	Inside	1.000
Bennett	21-22 Sept 83	Inside	.805
Evans 2	26, 27 Sept 83	Inside	.805
Kerr 1	27 Sept 83	Inside	.824
Kerr 2	13 Mar 84	Inside	.802
Kerr 3	8 May 84	Outside	.794
Verbinski 2	10 July 84	Outside	.789
Gold 2	17 July 84	Outside	1.000

Detailed correction factors supplied by Forehand and Hansen may disagree by a few percent from the general correction factors given in Table 1.

Number identifies different series of measurements.

Gold had corrected reactor power levels available for data reduction.

foils. The correction amounted to a revision upward of approximately 10% in the reactor fission rate - a revision downward in the fluence per fission. The correction improved the agreement between the fission foil measurements and the independent Feynman variance-to-mean measurements.

Forehand made a new S_n calculation of the ratio of fission rates on a radial traverse across the top of the fissile core, where the foils were located, to the core average fission rate using more detailed modeling of the reactor interior. He obtained 0.831 as the ratio of the fission densitiy on the axis of the core top to the average density. The value used in the original power calibration was 0.913. This change revised the reactor fission level upward approximately another 10%.

A comparison of the records of the power levels recorded at different times by the ionization chamber on the replica stand to those of other (older) chambers in the building indicated that the new chamber was losing sensitivity at the rate of 4.8% per year.

A least-squares analysis was made of the radiochemical data (corrected for fission product escape) and the ionization chamber readings (corrected for the drift just mentioned). The results are the revised calibration coefficients shown in Table 1. In addition to the calibration changes shown in the table, small changes were made for different range settings and for changes as faulty resistors were replaced. Complete calibration data for each of the approximately 500 runs of the replica are available.[1] We estimate an overall uncertainty of ± 4% in these revised calibration factors.

Table 2 gives correction factors to be applied to the calibration factors used in specific experiments.

Reference

1. Forehand, H. M. and Hansen, G. E., 1985. *Power Calibrations and Irradiation Histories of the Little Boy Comet Assembly for the Period 9/21/82 - 8/13/84*. Los Alamos, NM: Los Alamos National Laboratory, report Q2-85-WP5.