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CALIBRATION OF THE 10,000 CURIE COBALT-60 SOURCE

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ABSTRACT

This memo summarizes results of calibration of the nominal 10,000 curie cobalt-60 source operated by the Chemical Technology Division. As of April 30, 1960, the range of radiation levels achievable in the source extends from a minimum of 0.0076×10^{15} to 0.5×10^{15} ev/min-ml (of 0.4 M H_2O_2).

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INTRODUCTION

The purpose of this memo is to summarize data on the calibrations of the nominal 10,000 curie, cobalt-60 source operated by the Chemical Technology Division. These calibrations were performed with ceric sulfate solutions in the East Cavity of the facility[1] with the exception of one check calibration with ferrous sulfate solution. All calibrations were corrected to April 30, 1960.

Most of the experimental work of these calibrations was performed by C. T. Thompson; analyses of ceric sulfate solutions used to calibrate the central region were performed by members of L. C. Bate's groups of the Analytical Chemistry Division.

RESULTS

Calibrations were performed with the source capsule in the most elevated position, as shown in Fig. 1, and also with the capsule in its lowest position. These two extremes correspond to the ratchet pawl of the source positioning mechanism being at points T or 71 on the engraved ratched rack.

Calibrations with 100 ml of solution in 4 oz. bottles and with the source capsule in its lowest position show a small degree of radial asymmetry in the source, in the order of $\pm$ 3% (Table 1). Uncertainties in calibration data are known only for calibration with 100 ml of solution in the four corners. Relative standard deviations, based on 11 degrees of freedom, vary from 1% to 3.2% of the radiation level. Thus, it is doubtful that individual calibration points, such as the first five listed in Table 1 or those shown in Fig. 2, have less uncertainty than $\pm$5% of the value.

Radiation levels in the central section of the centering device vary with elevation when the source is in the lowered position. Fig. 2, wherein the vertical length of a line corresponds to the vertical location of the ceric sulfate solution, summarizes the variation of radiation level with elevation above the bottom of the cavity, i.e., above the 6 in. reference elevation of Fig. 1. The precision of the data of Fig. 2 is in the order of $\pm 0.5 \times 10^{18}$ ev/min-ml at the plateau value of about 6.5×10^{18} ev/min-ml, or 8-10% of the value. At the present time this is the only available estimate of the precision of the calibration of the central, high radiation level volume.

EXPERIMENTAL PROCEDURES

Ceric sulfate solutions were prepared from one of the following reagent materials obtained from the G. Frederick Smith Chemical Company: 1) $Ce(HSO_4)_4$; 2) 0.5 M $Ce(SO_4)_2$ in 1 M H_2SO_4; 3) $Ce(OH)_4$. Stock solutions, 0.04 M Ce(IV) and 0.4 M H_2SO_4, made from each

[1] W. Davis, Jr., "The Chemical Technology Division, 10,000 Curie Cobalt-60 Source: Description, Operating Procedures, and Safety Procedures," ORNL-CF-60-3-82, March 22, 1960.

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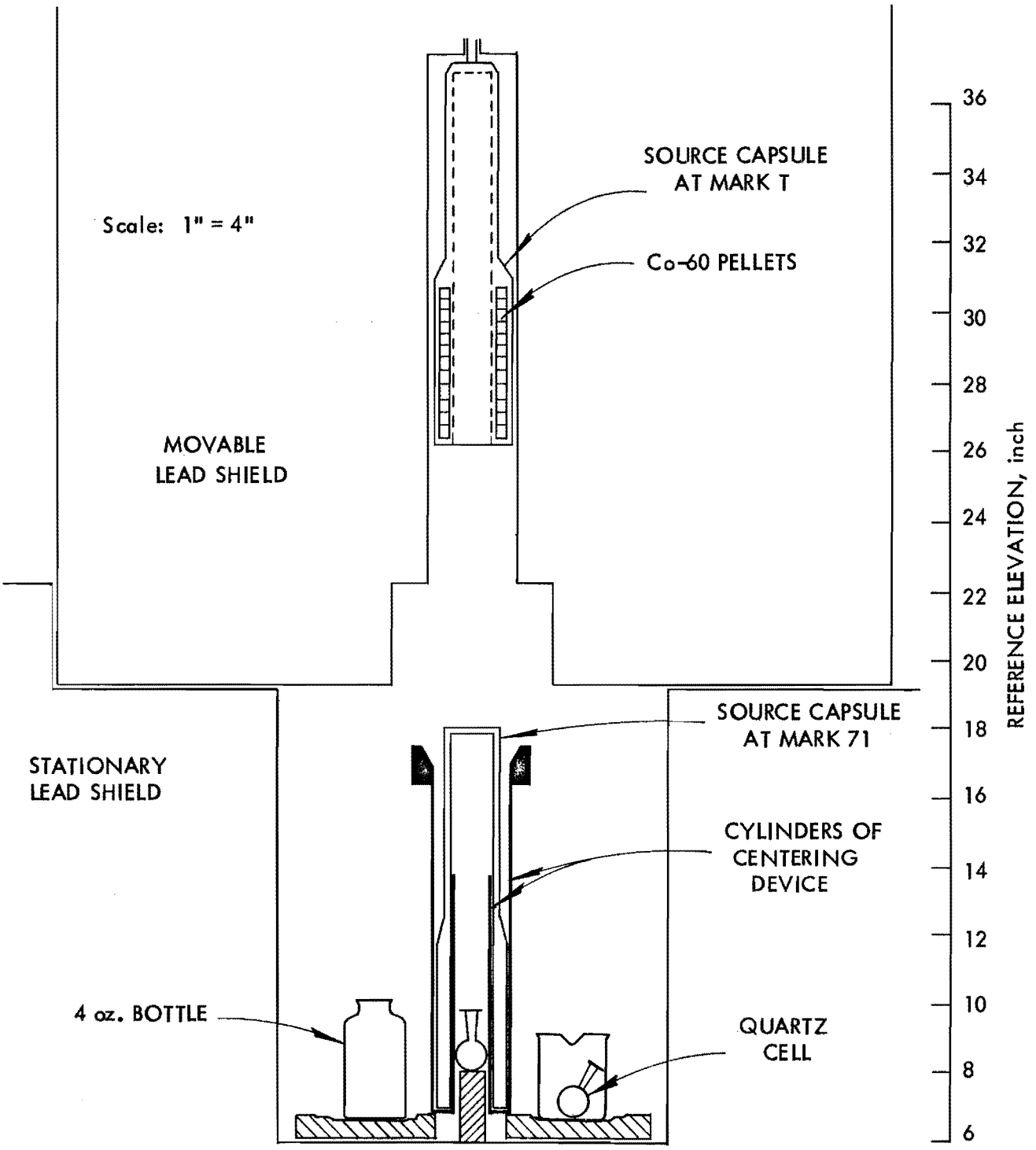

Fig. 1. Elevation of the East Cavity through the North-East to South-West corners (corners 1 and 3).

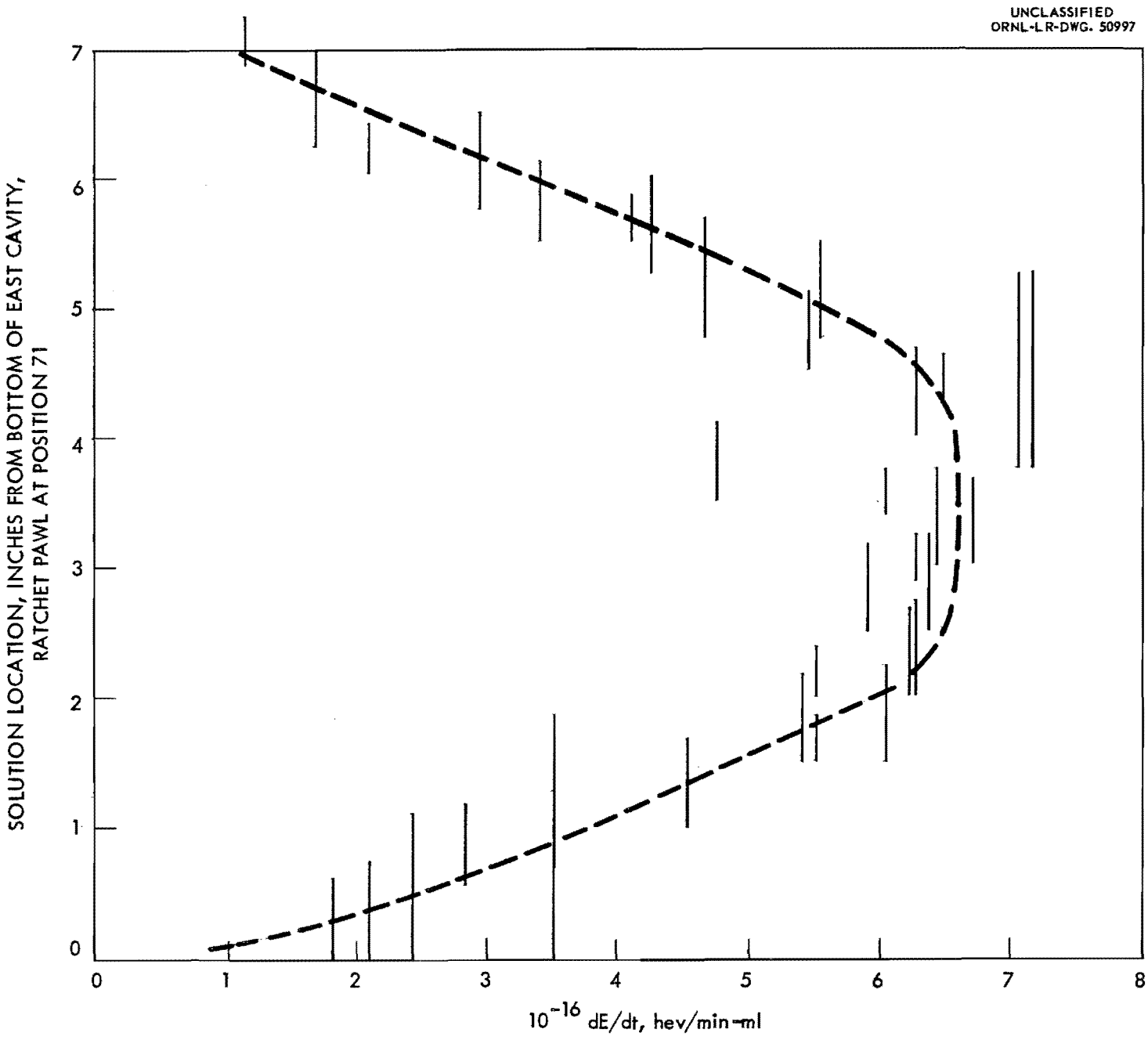

Fig. 2. Calibration of central volume of Cobalt-60 Source.

Table 1. Calibration of the 10,000 Curie Cobalt-60 Source

All data apply to April 30, 1960.

Ratchet Pawl Position[a]	Dosimeter Data			Radiation Density Based on 0.4 M H_2SO_4			
				$\frac{ev}{min-ml} \times 10^{-18}$		$\frac{watts}{liter}$	
	Type	Location[b]	Size	Average	Standard Deviation	Average	Standard Deviation
T	Ce(IV)	1(NE)	4 oz. Bot.	0.0076	--	0.0203	--
T	Ce(IV)	3(NW)	Quartz Cell	0.0102	--	0.0272	--
T	Ce(IV)	4(SW)	4 oz. Bot.	0.0097	--	0.0259	--
T	Ce(IV)	Center	Quartz Cell	0.0166	--	0.0443	--
T	Fe(II)	Center	Quartz Cell	0.0165	--	0.0441	--
71[c]	Ce(IV)	1(NE)	4 oz. Bot.	1.010	0.023	2.697	0.061
71[c]	Ce(IV)	2(SE)	4 oz. Bot.	1.034	0.016	2.762	0.044
71[c]	Ce(IV)	3(NW)	4 oz. Bot.	0.965	0.007	2.577	0.019
71[c]	Ce(IV)	4(SW)	4 oz. Bot.	0.994	0.032	2.655	0.086

[a]Position T corresponds to the source capsule being in the fully raised position; position 71 corresponds to the capsule being in its lowest position, which places the bottom of the capsule about 7/32 in. above the inside bottom of the source centering cylinder, Fig. 1.

[b]Letters in parentheses refer to the approximate compass bearing of the corner.

[c]11 degrees of freedom in each case.

of these were further diluted to appropriate values with 0.4 M H_2SO_4. All solutions were prepared with triply distilled water.

Each stock solution was tested for utility as a dosimeter by diluting a sample of it to 0.0004 M Ce(IV) in 0.4 M H_2SO_4 and exposing this to cobalt-60 gamma-radiation in an approximately 150 curie source.[2] The radiation density from this source was determined by Boyle and Mahlman[3] with the ferrous sulfate dosimeter, for which a $G\{Fe(III)\} = 15.60$ was used. Mahlman's[4] data were used in calculating values of $G\{Ce(III)\}$ at the various Ce(IV) concentrations used in these calibrations, as summarized by the following equations.

$$G\{H_2\} = -0.21\,[Ce(IV)]^{1/3} + 0.44, \quad \text{molecules/100 ev} \qquad (1)$$

$$G\{Ce(III)\} = 2.36 + 0.42\,[Ce(IV)]^{1/3}, \quad \text{ions/100 ev} \qquad (2)$$

Square brackets refer to activities, although concentrations were used in the actual calculations. Whenever an appreciable fraction of the Ce(IV) was converted to Ce(III), the average value of $G\{Ce(III)\}$, namely $\langle G\{Ce(III)\}\rangle$ was obtained by use of equation 3 where the subscript o refers to zero time and $R = [Ce(IV)]_t / [Ce(IV)]_o$.

$$\langle G\{Ce(III)\}\rangle = 2.36 + 3/4 \times 0.42\,[Ce(IV)]_o^{1/3} \left[\frac{1-R^{4/3}}{1-R}\right] \qquad (3)$$

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[2] J. R. Ghormley and C. J. Hochanadel, Rev. Sci. Inst., 22, 473 (1951).

[3] J. W. Boyle and H. A. Mahlman, ORNL Chemistry Division, private communication.

[4] H. H. Mahlman, J. Am. Chem. Soc., 81, 3203.

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