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LOW ENERGY X-RAY MEASUREMENTS OF SOME
TRANSURANIC ELEMENTS WITH A LITHIUM-
DRIFTED SILICON DETECTOR SYSTEM

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William H. Tyree

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Low Energy X-Ray Measurements of Some Transuranic Elements With a Lithium-Drifted Silicon Detector System

William H. Tyree

Abstract. A lithium-drifted silicon [Si(Li)] detector system has been used to measure the L X-ray photon energies of plutonium 238, plutonium 239, americium 241, and curium 244 with a measurement error of ± 50 electron volts.

DISCUSSION

The present developments in silicon and germanium detectors make good resolution possible of complex spectra. Considerable attention has been focused on these devices in recent years to result in what is considered as the advanced state of the art. Commercially available units have excellent resolution, an outgrowth of the intense interest in such devices.

The detectors have an immediate usefulness in making possible more accurate measurements of the emissions of radioisotopes. High photon efficiency and low intrinsic background of such detectors make them readily adaptable to high sensitivity spectrometers. In the area of health physics instrumentation, the advantage is the availability of large area, solid-state photon detectors applicable to whole-body counting and small-diameter, high resolution detectors useful in the medical treatment of wounds contaminated with radioactive isotopes.

Only the more obvious areas of health physics applications are noted. The whole area of health-physics monitoring services will eventually be improved by such devices.

Detector System: The detector, cryostat, and preamplifier used in the study were provided by the Technical Measurement Corporation of San Mateo, California.

The system includes an 80-millimeter squared (mm^2) by 3-mm deep detector with the first stage of the preamplifier built into the cryostat.

The 0- to 10-volt amplifier¹ used in the study was designed and built at Rocky Flats. It incorporates a linear-integrated circuit with a discrete transistor-output stage. The amplifier is compatible with standard Atomic Energy Commission modular electronics. The integrating-time constant used in the study was 1.2 microseconds.

A 512-channel, Nuclear Data ND-120 pulse-height analyzer with an internal window amplifier was used to collect the data.

Calibration: For calibration of the spectrometer system, use was made of americium 241 (^{241}Am) because of the accuracy obtained as given in the literature.² The Am isotope was also used as reference for all other runs. The L X-ray region of ^{241}Am was measured against the reference data by calculating the photon energy of the peaks located in the spectrum from two-known energy peaks with values³ of 13.96 and 17.76 kiloelectron volts (keV) and comparing the calculated values against the published data. The values agreed within the experimental error.

In Table I, results of the measurements are summarized.

Figures 1, 2, 3, and 4 show data obtained utilizing the Si(Li) detector system. The low energy L X-ray spectra are included to show characteristics of the emissions such as energy, nonsymmetry, and peak resolution. Peak heights do not necessarily indicate relative abundance, due to source-container absorption.

¹ W. H. Tyree. *An Integrated Circuit Amplifier*. RFP-964. Rocky Flats Division, The Dow Chemical Company, Golden, Colorado. (In Press.)

² E. K. Hyde, I. Perlman, and G. T. Seaborg. *The Nuclear Properties of the Heavy Elements*. Volume II. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1964.

³ L. B. Magnusson. "Intensities of X-Rays and γ Rays in Am^{241} Alpha Decay." *Physical Review*, 107:161. 1957.

TABLE I. The L X-Rays of Plutonium 238, Plutonium 239, Americium 241, and Curium 244. (Measurement error, ± 50 electron volts.)

Plutonium 238		Plutonium 239		Americium 241		Curium 244	
Energy (kiloelectron volts)	Full Width at Half Maximum (electron volts)	Energy (kiloelectron volts)	Full Width at Half Maximum (electron volts)	Energy (kiloelectron volts)	Full Width at Half Maximum (electron volts)	Energy (kiloelectron volts)	Full Width at Half Maximum (electron volts)
13.58	500	13.58	500	13.96*	620	14.31	620
15.53		15.75		16.09		16.48	
16.48		16.37		16.92		17.31	
17.20	670	17.20	620	17.76*	730	18.26	670
20.16	670	20.25	800	20.77	670	21.41	620
20.38				20.99		21.66	

* Americium 241 calibration peak energies assumed as 13.96 and 17.76 kiloelectron volts (see L. B. Magnusson).

FIGURE 1. Plutonium 238 (Ratio: kiloelectron volts/channel = 0.0553).

FIGURE 2. Plutonium 239 (Ratio: kiloelectron volts/channel = 0.0553).

FIGURE 3. Americium 241 (Ratio: kiloelectron volts/channel = 0.0553).

FIGURE 4. Curium 244 (Ratio: kiloelectron volts/channel = 0.0553).