Curium

What Is It? Curium is a hard, brittle, silvery metal that tarnishes slowly in dry air at room temperature. Curium does not occur naturally; it is typically produced artificially in nuclear reactors through successive neutron captures by plutonium and americium isotopes. Sixteen isotopes of curium are known to exist, and all are radioactive. (Isotopes are different forms of an element that have the same number of protons in the nucleus but a different number of neutrons.) Curium was first produced in 1944 by bombarding plutonium-239 with alpha particles in a cyclotron at the University of California at Berkeley. Curium was isolated in visible amounts as the hydroxide in 1947 and is named in honor of Pierre and Marie Curie, who pioneered the study of radioactivity.

Symbol: Cm

Atomic Number: 96
(protons in nucleus)

Atomic Weight: -
(not naturally occurring)

Eight of the sixteen curium isotopes have half-lives greater than one month. Curium-243 and curium-244 are the two isotopes of most concern at Department of Energy (DOE) environmental management sites such as Hanford. The curium-242 produced more than 20 years ago has essentially all decayed away, and the low specific activities of the other curium isotopes limit their radiological hazards. In addition, the longer-lived isotopes typically represent much less than 1% of the curium inventory at a site. Curium generally decays to plutonium by emitting an alpha particle; gamma radiation is associated with some of these decays. A relatively small percentage (14%) of curium-250 decays are by beta-particle emission to berkelium-250. Curium-248 and curium-250 also decay by spontaneous fission (SF), a process in which the atom self-disintegrates into two smaller atoms accompanied by a release of energy. (A very small fraction of curium-242, curium-244, and curium-246 decays are also by SF.)

Radioactive Properties of Key Curium Isotopes and Associated Radionuclides

Isotope	Half-Life	Specific Activity *(Ci/g)*	Decay Mode	Radiation Energy *(MeV)*		
				Alpha (α)	Beta (β)	Gamma (γ)
Cm-242	160 days	3,400	α	6.1	0.010	0.0018
Cm-243	29 yr	52	α	5.8	0.14	0.13
Cm-244	18 yr	82	α	5.8	0.086	0.0017
Cm-245	8,500 yr	0.17	α	5.4	0.065	0.096
Cm-246	4,700 yr	0.31	α	5.4	0.0080	0.0015
Cm-247	16 million yr	0.000094	α	4.9	0.021	0.32
Pu-243	*5.0 hr*	*2.6 million*	*β*	-	*0.17*	*0.026*
Cm-248	340,000 yr	0.0043	α	4.7	0.0060	0.0012
Cm-250	6,900 yr	0.21	α, β	1.3	0.0016	-
Pu-246 (25%)	*11 days*	*49,000*	*β*	-	*0.13*	*0.14*
Bk-250 (14%)	*3.2 hr*	*3.9 million*	*β*	-	*0.29*	*0.89*
Am-246 (25%)	*39 min*	*20 million*	*β*	-	*0.66*	*0.70*

Ci = curie, g = gram, and MeV = million electron volts; a dash indicates the entry is not applicable. (See the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients for an explanation of terms and interpretation of radiation energies.) About 8% of the decays of curium-248 are by spontaneous fission (SF), with alpha-particle decay occurring 92% of the time. 61% of the curium-250 decays are by SF, with alpha-particle emission (25%) and beta-particle emission (14%) accounting for the remainder. Certain properties of plutonium-243, plutonium-246, berkelium-250, and americium-246 are included here because these radionuclides accompany the curium. Values are given to two significant figures.

Where Does It Come From? Although the presence of natural curium has never been detected, minute amounts may exist in some uranium ores. Curium is a byproduct of plutonium production activities and results from the successive capture of neutrons by plutonium and americium, generally in nuclear reactors.

How Is It Used? Curium has few uses outside of research activities, and it is only available in extremely small quantities. Curium isotopes can be used without heavy shielding as sources of thermoelectric power in satellites and crewless space probes. Curium-242 has been used in isotopic power generators because it produces about 3 watts of heat energy (from radioactive decay) per gram. Curium-242 was used on lunar missions to bombard the moon’s soil with alpha particles to determine what it was made of. Instruments analyzed the characteristics of the scattered alpha particles from the moon’s surface, from which it was determined that lunar soil was similar in composition to basalt, a common terrestrial volcanic rock. The high specific activity of curium-242 coupled with its low external hazard made this isotope an ideal choice for such an application.

What's in the Environment? Atmospheric testing of nuclear weapons, which ceased worldwide by 1980, generated most environmental curium. Accidents and other releases from weapons production facilities have caused localized contamination. Curium oxide is the most common form in the environment. Curium is typically quite insoluble and adheres very tightly to soil particles. The concentration of curium in sandy soil particles is estimated to be about 4,000 times higher than in interstitial water (in pore spaces between soil particles), and it binds even more tightly to loam soil where concentration ratios are even higher (18,000).

What Happens to It in the Body? Curium can be taken into the body by eating food, drinking water, or breathing air. Gastrointestinal absorption from food or water is the most likely source of any internally deposited curium in the general population. After ingestion, most curium is excreted from the body within a few days and never enters the bloodstream; only about 0.05% of the amount ingested is absorbed into the bloodstream. Of the curium that reaches the blood, about 45% deposits in the liver where it is retained with a biological half-life of 20 years, and 45% deposits in bone where it is retained with a biological half-life of 50 years (per simplified models that do not reflect intermediate redistribution). Most of the remaining 10% is directly excreted. Curium in the skeleton is deposited mainly on the endosteal surfaces of mineral bone and only slowly redistributes throughout the bone volume.

What Are the Primary Health Effects? Curium is generally a health hazard only if it is taken into the body; however, a small external risk is associated with curium-243, curium-245, curium-247, and curium-250 (note that the SF contribution from curium-250 is not quantified). People can be exposed by ingesting contaminated food or water or by inhaling contaminated dust. Ingestion is generally the exposure route of concern unless a nearby source of dust contamination exists. Because curium is absorbed within the body much more readily if inhaled rather than ingested, both exposure routes can be important. The main health concern is bone tumors resulting from ionizing radiation emitted by curium isotopes deposited on bone surfaces.

What Is the Risk? Lifetime cancer mortality risk coefficients have been calculated for nearly all radionuclides, including curium *(see box at right)*. Although ingestion is generally the most common exposure, these risk coefficients are much lower than those for inhalation. As for other nuclides, the risk coefficient for tap water is about 80% of that shown for dietary ingestion. In addition to risks from internal exposures, a risk from external gamma exposure is associated with curium-243, curium-245, curium-247, and curium-250. Using the external gamma risk coefficients to estimate lifetime cancer mortality risks, if it is assumed that 100,000 people were continuously exposed to a thick layer of soil with an initial average concentration of 1 pCi/g, then 1 person would be predicted to incur a fatal cancer if the soil contained curium-243, 1 if it contained curium-245, 6 if it contained curium-247, and 7 if it contained curium-250 (from its short-lived decay products). (This compares to 20,000 people from the group predicted to die of cancer from all other causes per the U.S. average.) The external risk coefficients for the other curium isotopes are less than 1% of those for these four. About 8% of curium-248 decays and 61% of curium-250 decays are by SF. No detailed information has been compiled on the SF radiation field (neutron and gamma rays) associated with distributed sources of radionuclides in soil. This is because radionuclides with a significant SF yield are not usually found in the

Radiological Risk Coefficients

This table provides selected risk coefficients for inhalation and ingestion. Recommended default absorption types were used for inhalation, and dietary values were used for ingestion. Risks are for lifetime cancer mortality per unit intake (picocurie, pCi), averaged over all ages and both genders (10^{-9} is a billionth, and 10^{-12} is a trillionth). Other values, including for morbidity, are also available. Because risk values are not available for curium-248 and curium-250, these were estimated by multiplying the risk factors for curium-246 by the ratios of the dose conversion factors for curium-248 and curium-250 to curium-246.

Isotope	Lifetime Cancer Mortality Risk	
	Inhalation (pCi^{-1})	Ingestion (pCi^{-1})
Curium-242	1.4×10^{-8}	3.2×10^{-11}
Curium-243	2.4×10^{-8}	8.5×10^{-11}
Curium-244	2.3×10^{-8}	7.5×10^{-11}
Curium-245	2.4×10^{-8}	9.5×10^{-11}
Curium-246	2.4×10^{-8}	9.3×10^{-11}
Curium-247	2.2×10^{-8}	9.1×10^{-11}
Curium-248	*8.8×10^{-8}*	*3.4×10^{-10}*
Curium-250	*5.0×10^{-7}*	*2.0×10^{-9}*

For more information, see the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients and the accompanying Table 1.

environment, and if present they are at extremely low levels. Thus, no standard values are available to estimate the dose or risk from external exposure to curium-248 or curium-250 that accounts for the SF dose component.