Americium

What Is It? Americium is a malleable, silvery white metal that tarnishes slowly in dry air at room temperature. Americium does not occur naturally but is produced artificially by successive neutron capture reactions by plutonium isotopes. There are sixteen known isotopes of americium and all of them 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.) Americium-241 was first produced in 1944 in a nuclear reactor at the University of Chicago. Dr. Glenn Seaborg gave the new element its name in 1946 in honor of the continent on which it was discovered.

Symbol: **Am**

Atomic Number: **95**
(protons in nucleus)

Atomic Weight: **-**
(not naturally occurring)

Of the sixteen radioactive isotopes, only three have half-lives long enough to warrant concern at Department of Energy (DOE) environmental management sites: americium-241, americium-242m, and americium-243. The half-lives of these three isotopes range from 150 to 7,400 years, while those of the other isotopes are less than a day. Americium-241 is generally the most prevalent isotope at DOE sites such as Hanford. It has a half-life of 430 years and decays by emitting an alpha particle with attendant gamma radiation. The other two isotopes typically represent less than a few percent of the total americium inventory at a site. Americium-242m (the "m" means metastable) has a half-life of 150 years, and it decays by isomeric transition. Americium-243 is generally not a major concern at DOE sites given its low abundance relative to americium-241 and low specific activity.

Radioactive Properties of Key Americium Isotopes and Associated Radionuclides

Isotope	**Half-Life**	**Specific Activity** *(Ci/g)*	**Decay Mode**	**Radiation Energy** *(MeV)*		
				Alpha (α)	**Beta** (β)	**Gamma** (γ)
Am-241	430 yr	3.5	α	5.5	0.052	0.033
Am-242m	150 yr	9.8	IT	0.025	0.044	0.0051
Am-242	*16 hr*	*820,000*	β, *EC*	-	*0.18*	*0.018*
Am-243	7,400 yr	0.20	α	5.3	0.022	0.055
Np-239	*2.4 days*	*230,000*	β	-	*0.26*	*0.17*

IT = isomeric transition, EC = electron capture, Ci = curie, g = gram, and MeV = million electron volts; a dash means that 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.) Americium-242 decays by two means: by emitting a beta particle (83%) and by electron capture (17%). Certain properties of americium-242 and neptunium-239 are included here because these radionuclides accompany the americium decays. Values are given to two significant figures.

Where Does It Come From? Americium is a byproduct of plutonium production activities and results from the successive capture of neutrons by plutonium. The most common isotope is americium-241, a decay product of plutonium-241. When plutonium-239 absorbs two neutrons it produces plutonium-241, which decays by emitting a beta particle with a fairly short half-life of 14 years to generate americium-241. Americium-243 is produced in a similar manner from the decay of plutonium-243, which decays by emitting a beta particle with a half-life of 5 hours. Successive neutron absorptions of the isotope americium-241can produce both americium-242m and americium-243.

How Is It Used? The most common use of americium is in smoke detectors. These detectors rely on the alpha particle associated with the decay of americium-241 to ionize the air in a gap between two electrodes, causing a very small electrical current to flow between them. When smoke enters the space between the electrodes, the alpha radiation is absorbed by the soot particles, the current is interrupted, and the alarm is sounded. Alpha particles from smoke detectors do not themselves pose a health hazard, as they are absorbed in a few centimeters of air or by the structure of the detector. Americium is also used as a portable source for gamma radiography, for crystal research, and as target material in nuclear reactors or particle accelerators to produce even heavier elements. A common neutron source is composed of americium-241 and beryllium. The alpha particle given off during the radioactive decay of americium-241 is absorbed by beryllium-9, producing carbon-12 and a neutron. Such devices can be used for the nondestructive testing of machinery and equipment and for other industrial applications.

What's in the Environment? Atmospheric testing of nuclear weapons, which ceased worldwide by 1980, generated most environmental americium. Accidents and other releases from weapons production facilities have caused localized contamination. Americium oxide is the most common form in the environment. Average americium-241 levels in surface soil are about 0.01 picocuries (pCi)/g. Americium is typically quite insoluble, although a small fraction can become soluble through chemical and biological processes. It adheres very strongly to soil, with americium concentrations associated with sandy soil particles estimated to be 1,900 times higher than in interstitial water (the water in the pore spaces between the soil particles); it binds more tightly to loam and clay soils so those concentration ratios are even higher. At DOE sites such as Hanford, americium can be present in areas that contain waste from the processing of irradiated fuel.

What Happens to It in the Body? Americium can be taken into the body by eating food, drinking water, or breathing air. Gastrointestinal absorption from food or water is a likely source of internally deposited americium in the general population. After ingestion or inhalation, most americium is excreted from the body within a few days and never enters the bloodstream; only about 0.05% of the amount taken into the body by ingestion is absorbed into the blood. After leaving the intestine or lung, about 10% clears the body. The rest of what enters the bloodstream deposits about equally in the liver and skeleton where it remains for long periods of time, with biological retention half-lives of about 20 and 50 years, respectively (per simplified models that do not reflect intermediate redistribution). The amount deposited in the liver and skeleton depends on the age of the individual, with fractional uptake in the liver increasing with age. Americium in the skeleton is deposited uniformly on cortical and trabecular surfaces of bones and slowly redistributes throughout the volume of mineral bone over time.

What Are the Primary Health Effects? Americium is generally a health hazard only if it is taken into the body, although there is a small risk associated with the gamma rays emitted by neptunium-239, a radioactive decay product of americium-243. The main means of exposure are ingestion of food and water containing americium isotopes and inhalation of americium-contaminated dust. Ingestion is generally the exposure of concern unless there is a nearby source of contaminated airborne dust. Because americium is taken up in the body much more readily if inhaled rather than ingested, both exposure routes can be important. The major health concern is tumors resulting from the ionizing radiation emitted by americium isotopes deposited on bone surfaces and in the liver.

What Is the Risk? Lifetime cancer mortality risk coefficients have been calculated for nearly all radionuclides, including americium *(see box at right)*. While ingestion is generally the most common type of exposure, the risk coefficients for this route are much lower than those for inhalation. As for other nuclides, the coefficient for tap water is about 80% of that shown for dietary ingestion.

In addition to risks from internal exposures, there is an external gamma exposure risk associated with americium-243. To estimate a lifetime cancer mortality risk, 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 americium-243, then 3 of these 100,000 people would be predicted to incur a fatal cancer. (This is in comparison to the 20,000 people from the group predicted to die of cancer from all other causes per the U.S. average.) This risk is largely associated with the gamma ray emitted by its short-lived decay product neptunium-239. The external risk for the other two americium isotopes is less than 10% of that for americium-243.

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. These values include the contributions from the short-lived americium decay products. Risks are for lifetime cancer mortality per unit intake (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.

Isotope	Lifetime Cancer Mortality Risk	
	Inhalation *(pCi^{-1})*	**Ingestion** *(pCi^{-1})*
Americium-241	2.4×10^{-8}	9.5×10^{-11}
Americium-242m	1.3×10^{-8}	6.8×10^{-11}
Americium-243	2.3×10^{-8}	9.8×10^{-11}

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