UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Fact Sheet

Office of Public Affairs
Telephone: 301/415-8200 E-mail: opa@nrc.gov

Plutonium

Plutonium is a radioactive, metallic element with atomic number 94. It was discovered in 1940 at the University of California, Berkeley. It has several unique properties which make it both very useful and potentially dangerous to handle.

Because plutonium occurs in nature in only minute amounts, it must be considered for all practical purposes a man-made element (some pitchblende ores, once a main source of uranium and radium, contain one part per trillion natural plutonium).

Plutonium Isotope Half-lives

There are 15 isotopes (another form) of plutonium. Some isotopes of plutonium are fissionable meaning that the atomic nucleus is unstable and will split apart, resulting in the release of large amounts of energy. Pu-239 and Pu-241 are the most abundant of the fissionable isotopes of plutonium.

A half-life is the time in which one half of the atoms of a radioactive substance disintegrates into another nuclear form, hence, the time to halve its radioactive strength. Pu-239 has a half-life of 24,000 years and Pu-241's half-life is 14.4 years. The plutonium isotope with the shortest half-life of 20 minutes is Pu-233. Plutonium-244, which occurs naturally, has the longest half-life of 80,000,000 years.

Source of Plutonium

Plutonium is created by the absorption of neutrons by uranium. Plutonium was first made in large quantities in the World War II Manhattan Project for use in atomic bombs. Because it is fissionable, it also can be used, under different circumstances, as fuel for reactors. Present day light water reactors create plutonium as the uranium fissions (splitting of atoms). Some of the neutrons released during the fissioning of uranium interact with yet other uranium atoms to form, plutonium. Some of this plutonium created in the fuel of the reactor core is itself fissioned thereby helping to sustain the chain reaction of splitting atoms. The plutonium which does not fission by the end of the core’s life remains in the fuel rod.

Plutonium-238, in addition to its ability to fission, is self-heating and can be potentially valuable in thermoelectric generators for use in space program instruments and heart pacemakers.

Pathways in the Body

The most common form of plutonium is plutonium oxide which is virtually insoluble. The behavior of plutonium oxide in the body varies with the way in which it is taken. If one drinks or eats it, a very large percentage of it will be eliminated from the body quite rapidly in body wastes. If plutonium oxide is inhaled, part of it, usually between 20 and 60 percent depending upon such things as the size of the particles, is retained in the lung. The rest is eliminated from the body within several days. Of that which remains in the lungs, about half will be removed each year, some to be excreted, some to lodge in the lymph nodes, and a very small amount will be deposited in other organs, mainly bone. If plutonium enters the body through an open wound, depending on its form, it may move directly into body organs, mainly bone and liver.

The next most common form of plutonium is plutonium nitrate-a chemical that is somewhat more soluble than the oxide. Plutonium nitrate’s behavior in the body is similar to plutonium oxide, however, it moves out of the lung more rapidly.

Radiological Considerations

Since plutonium was discovered in 1940, it was not a part of the extensive radiological experience of the pre-World War II decades. By the time it was evident that plutonium would be available in substantial quantities, the scientific community was well aware that highly radioactive material could be hazardous. In some ways, plutonium was less hazardous than some other radioactive materials then in use. Plutonium does not produce strong, penetrating radiation nor is it hard to contain. But it is a long-lived alpha emitting material that, if it gets inside the body, could deposit in the bones or in lungs and possibly increase an individual’s cancer risk. Therefore, very low limits were established for exposure to plutonium.

Toxicity

Recent research with one of the least radioactive isotopes of plutonium (plutonium-242, which has a half-life of 376,000 years) indicates that plutonium in the body may contribute to the development of tumors. In general, however, plutonium isotopic mixtures that are commonly encountered in the nuclear fuel cycle, nuclear weapons programs, or thermoelectric generator applications exhibit much higher radiological toxicity than chemical toxicity.

Production and Disposition

Over 1500 metric tons of plutonium have been produced world wide, some for weapons use, and most of the rest as a by-product of electricity production. It is important to note that the plutonium produced as a by-product in a nuclear power reactor is created in its many isotopic forms, including Pu-239, Pu-240, Pu-241, and Pu-242. This is known as “reactor-grade” plutonium. In contrast, “weapons-grade” plutonium contains almost pure (over 90%) Pu-239.

Plutonium-239 is created in a reactor that is specially designed and operated to produce Pu-239 from uranium.

With the end of the Cold War, the United States and the former Soviet Union began dismantling thousands of nuclear weapons which has resulted in a surplus of highly enriched uranium and plutonium. To dispose of this surplus and protect against it falling into the wrong hands, the U.S. has plans to mix the plutonium with uranium to make mixed oxide (MOX) fuel for power reactors. The intent of the MOX fuel program is to irradiate the so called "weapons-grade" plutonium, converting it to "reactor-grade," which will make the plutonium no longer suitable for use in advanced nuclear weapons. There would be no reprocessing or subsequent reuse of the MOX spent fuel. The fuel would be disposed of in a waste repository along with other high-level nuclear waste.

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