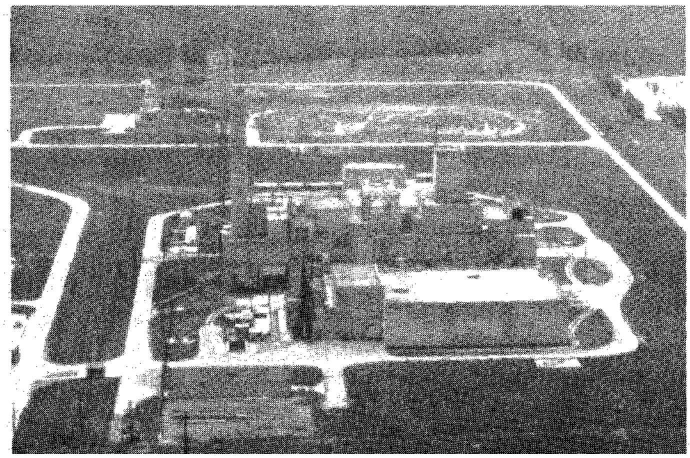
Plutonium at the Savannah River Site

History of the Savannah River Site

Beginning in 1953, the Du Pont Company produced plutonium and tritium at the Savannah River Site (SRS) for the United States government. Construction of the SRS complex began in February of 1951. In a two-year period (using up to 39,000 workers and 54-hour work weeks), Du Pont constructed five nuclear reactors, two large chemical processing plants and other facilities essential to create and process nuclear weapons materials. In December of 1953 the R reactor was brought online, and in June of 1954 the first irradiated fuel was removed from the reactor. Beginning in November of 1954, plutonium was extracted from the fuel in a chemical processing facility called the 221-F canyon. Tritium, the other primary SRS product, was extracted from reactor-irradiated lithium-aluminum targets beginning in October 1955 in the 200-F area. Production of these and other nuclear materials continued at the site for the next 30 years.

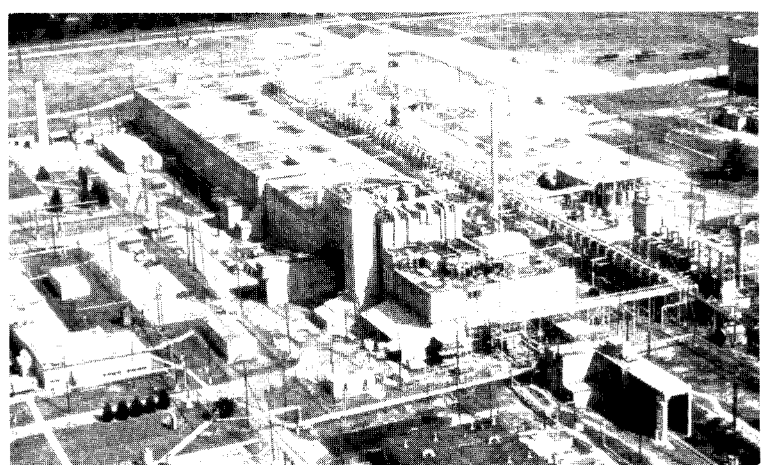


An early view of one of the SRS reactor complexes. The reactor is located under the tall building at the rear of the complex. The reactor stack is to the left of the reactor.

Studying SRS Operations

A number of steps in the SRS plutonium processing and waste management operations had the potential to release plutonium, tritium and other materials to the environment.

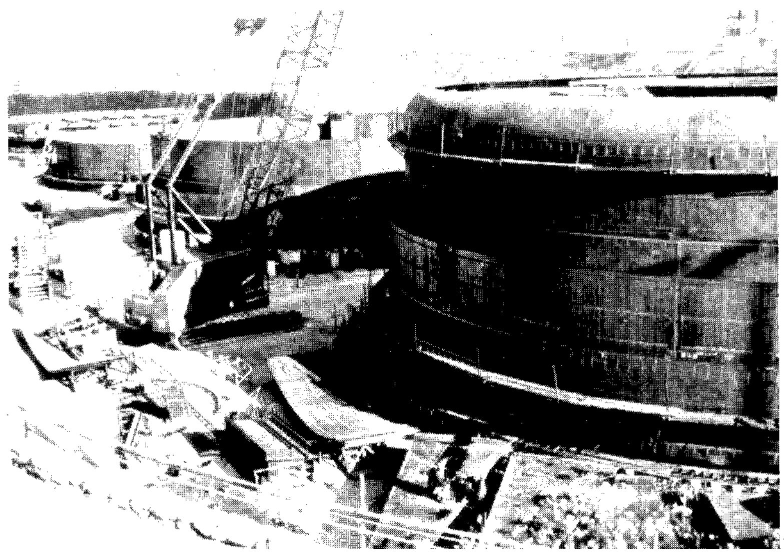
Through Phase II of its Environmental Dose Reconstruction Project, the Centers for Disease Control and Prevention (CDC) and its contractor, Radiological Assessments Corporation, are examining the history of SRS operations to estimate the magnitudes of such releases and possible health impacts.



One of the two SRS chemical processing facilities, also referred to as canyons. Beginning in 1954, these processing facilities dissolved highly radioactive fuel and targets from the reactors, and chemically separated plutonium, tritium and other products

Many tons of plutonium were produced, purified and shipped to other U.S. weapons facilities during the 30 years of primary SRS operations. Radionuclides including plutonium were routinely released in small quantities as particles from SRS stacks and vents, and on occasion as a result of filter failures or other accidents. In addition, materials were released to area streams and groundwater, during normal operations and as a result of early methods of handling wastes. High-level wastes were stored in very large underground steel tanks onsite; some leakage from these tanks occurred over the years. Lower-level wastes were routinely released to streams, earthen seepage basins and ponds. Some radionuclides such as tritium moved quickly through streams and groundwater, finding their way offsite, usually to the Savannah River. Other radionuclides including plutonium tended to remain behind when released to surface or groundwater, and were less likely to move rapidly offsite. Because plutonium-239 (Pu-239, the primary plutonium isotope produced in the SRS reactors) remains in the environment for thousands of years, some people living near the SRS have expressed concern about potential health impacts from past releases of plutonium and other materials.

Understanding the physical, chemical and biological nature of plutonium is important to CDC's research.



Several 1.3-million gallon high-level liquid waste storage tanks under construction at the SRS during the early years. These tanks were subject to corrosion, cracking, and some leakage over the years. Because of the very large quantities of highly radioactive materials stored in these tanks, their performance is being carefully studied during the dose reconstruction project.

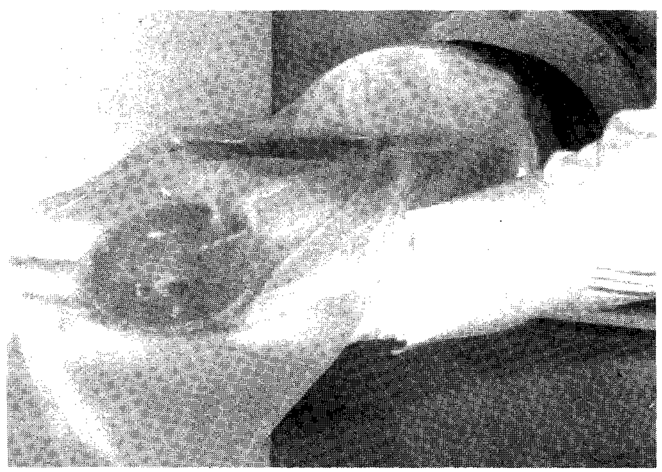
Characteristics of Plutonium (Pu)

Plutonium-239 has a half-life of 24,000 years. This means that half of the quantity present today will still be present in 24,000 years; the remainder will have decayed radioactively. The decay process releases alpha particles, which are known to damage living tissue. This damage is what is responsible for plutonium's health hazard. Other plutonium isotopes, including Pu-238 and Pu-240, were also produced at SRS, but in smaller quantities.

Several characteristics of plutonium influence its biological impact:

- Plutonium, unlike most radioactive materials, is not a hazard when it remains outside the body. This is because alpha particles cannot penetrate the layer of dead skin that covers the body. Pu-239 does not emit significant penetrating radiation (such as gamma rays or beta particles).

- However, when plutonium enters the body and is deposited in or on living tissue, it is very hazardous. The alpha particles, tiny pieces of the atom's nucleus, are energetic and can injure living cells. When they pass through tissue, they can damage DNA and other cell components. Cancer may develop in the damaged tissue.
- Plutonium can enter the body through two main routes: 1) by breathing contaminated particles suspended in the air, or 2) by eating or drinking contaminated foods or liquids.
- The common chemical forms of plutonium found in the environment do not dissolve easily in body fluids. Therefore, ingested plutonium tends to pass through the digestive tract without being taken into the bloodstream and moving to other organs.
- Inhalation of airborne plutonium particles is the main route of concern. Radioactive particles deposited in the lung can directly irradiate lung tissue; most will also move from the lung over time and may enter and damage other organs.
- During past operations at SRS, only the smaller particles of plutonium remained airborne for long periods (hours or days) after being released into the air. These smaller particles could drift offsite and become available for inhalation by members of the public. A significant fraction of inhaled small particles would have been immediately exhaled without "sticking" in the lungs; most of the remaining material would eventually move from the lungs to the GI tract and out of the body.
- However, of the material deposited in the lungs, some would be expected to move to blood and lymph systems and eventually to other parts of the body. Approximately 80% of this portion of the material would eventually be deposited in liver and bone, although the fractions to these organs varies with age because of the growth of the skeleton in the young. After plutonium is deposited in organs, it is eliminated only very slowly from the body, and continues to emit alpha particles as it decays.
- There are chemical agents that can be used to hasten the removal of plutonium from the body. However, because of side effects, such "chelating agents" were rarely used, and only when a high, accidental exposure to a plutonium worker occurred.



A radioactive plutonium metal "button" produced since the mid-1950s at the SRS. Because alpha particles are stopped very quickly in solid matter, the operator is protected both by the plastic on which the material rests, and by the dead layer of skin covering his hand.

Health Studies

Animal research has shown that plutonium in the body can lead to cancers of the lung, bone and liver. The effects of exposures to radiation occur randomly in groups of people exposed. At low doses, only a small fraction of an exposed group will be affected. Cancer is a relatively common disease; research studies must be able to show a statistically significant excess of a cancer type before a relationship with radiation exposure can be demonstrated.

Studies of workers exposed to plutonium have been performed, but until recently the number of significantly exposed workers available to study has been small, and clear evidence of plutonium-induced cancer had not been found. Recently, data has become available to perform studies of Russian defense plant workers highly exposed to plutonium beginning in the 1950s. These studies have demonstrated a link between human exposures to plutonium and excess lung cancer.

Dose and Risk From Plutonium

While nonworker groups have been exposed to plutonium from weapons facilities and atmospheric testing, plutonium-related effects have not become evident in these low-exposure groups. However, it is considered reasonable to calculate the exposures, doses and health risks to such low-exposure groups, even though it is not statistically possible to identify cancers caused by low-level exposures to plutonium. The evidence gathered from studies such as those of the Russian workers can be used to extrapolate to estimate the effects of low-level plutonium exposures. For example, the U.S. Environmental Protection Agency, the National Council on Radiation Protection and Measurements, and the International Council on Radiation Protection (ICRP), as well as a number of other organizations worldwide, have developed specific recommendations for the estimation of risk from exposures to plutonium and other radionuclides.

Such methods and data for calculating the dose and risk from human intake of plutonium are continually evolving. The ICRP regularly publishes reports from which groups within the U.S. and elsewhere develop their own standards and methods for plutonium and other radionuclide risk evaluation. The CDC will use the latest information and methods for calculating plutonium dose and risk.

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