DOE NNSA Fissile Materials

INTRODUCTION

Fissile materials are a subset of nuclear materials that are capable of undergoing fission. Fission is the splitting of an atom that results in the release of a large amount of energy. Plutonium (Pu) and highly enriched uranium (HEU) are the primary nuclear materials used as the explosive components of nuclear warheads.

FISSILE MATERIAL CHARACTERISTICS

Plutonium is a brittle, highly dense, radioactive heavy metal with a silvery surface similar in appearance to nickel. Plutonium reacts chemically (oxidizes) when it is exposed to moist air. Finely divided plutonium metal dust ignites (catches fire) spontaneously in the presence of air-, but this cannot happen with the larger forms of plutonium found in weapons. Plutonium has 15 isotopes, all of which are radioactive. Isotopes are different types of the same chemical element having different numbers of neutrons and the same number of protons. Neutrons and protons are the principal parts of an atom's nucleus.

Uranium is a natural substance widely distributed over the earth. It is a heavy metal, silvery white in color, a little softer than steel, and with metallurgical characteristics similar to iron. Like plutonium uranium slowly oxidizes when exposed to air, and in a fine powder or chip form, is capable of spontaneous combustion. Uranium has 18 isotopes, all of which are radioactive. Naturally occurring uranium consists primarily of uranium-238. Only 0.7% of any given quantity of natural uranium is the fissile isotope uranium-235 (U235).

FISSILE MATERIAL USE

The principal plutonium isotope used in weapons is plutonium-239. Plutonium was produced in nuclear reactors at the Hanford and Savannah River Sites for the sole purpose of making nuclear weapons. Once the need for additional weapons ceased, the nuclear reactors were shut down. No plutonium for weapons has been produced since 1988. Other countries use plutonium as a fuel for commercial nuclear reactor power plants; however, it is not used for this purpose in the United States.

The ability to use uranium for fission in nuclear chain reactions requires increasing the proportion of the U-235 isotope in the material through an isotopic separation process called "enrichment." HEU is material with an isotope concentration equal to or greater than 20% U-235. Highly enriched uranium is used in research, in test and naval reactors, and in nuclear weapons. The production of HEU in the United States was discontinued in 1992 because of the size of the inventory and projections of limited future need.

HEALTH EFFECTS

Radioactive decay is the process by which an unstable atom, like plutonium or uranium, is transformed (decays) into another atom. The radiation emitted during plutonium or uranium decay is primarily alpha particles. Outside the body, alpha particles are not very hazardous - a sheet of paper will stop an alpha particle. However, beta particles, neutrons, and gamma rays, which are all more penetrating than alpha particles, are also emitted. In addition, plutonium has a toxicity associated with its radioactivity.

The two primary routes through which plutonium or uranium particles could enter the body are through ingestion or inhalation. Particles on a person's skin are not readily absorbed and can be washed off. If particles are ingested and enter the body's digestive system, very little of the plutonium or uranium is absorbed, and most is naturally excreted within a few days.

Fissile materials can be hazardous when they enter the body through the lungs. If plutonium or uranium is inhaled, the fine particles can be deposited in the lungs and then transported to bones and other vital organs, such as the kidneys and liver, where chemical toxicity could alter normal body cell functions and lead to cell death. Alpha particles inside the body cause genetic changes in cells that may increase the risks of cancer over time.

HANDLINIG SAFETY

In the past fifty years, DOE has learned to work with the hazards associated with plutonium and uranium, and many ways to safely handle these fissile materials have been developed. These precautions include containing the material in a tightly sealed system, shielding

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the radiation emitted by its decay, and preventing criticality. Criticality is a condition in which the amount of fissile material will allow a nuclear reaction.

Protective clothing is used to prevent both contamination of the body or personal items and the transfer of contaminated materials to clean areas. Clothing requirements depend on the type and amount of material being handled, but protective clothing typically includes gloves, shoes, laboratory coats, coveralls, and head covers. People working with fissile materials are trained in their characteristics and safe handling and are equipped with respiratory protection whenever there is a chance that plutonium or uranium particles might be inhaled. Employees and the workplace, including the ventilation systems are monitored routinely to ensure that employees are safe and that fissile - materials are confined within the facility. In addition, the air, water, and soil surrounding these facilities are routinely monitored to ensure that the community is safe from unacceptable levels of radiation.

Facilities handling plutonium have additional protective barriers that include sophisticated ventilation systems with multiple banks of high efficiency filters to trap any particles before they can escape into the air. Containment devices, like glove boxes, are used to confine plutonium and ensure that employees and the public are not exposed to the material. These glove boxes contain low relative humidity, which inhibits chemical reaction. To prevent criticality, plutonium operations and processing are controlled so that the amount and shape of the plutonium at any time is maintained to prevent a nuclear reaction.

The Department follows the principle of keeping employee and public exposure to radiation As Low As Reasonably Achievable (ALARA). Using shielding, distance, and time to minimize exposure to penetrating radiation to accomplish adherence to this principle. DOE continuously looks for safer methods to minimize exposure which are then reflected in new or revised policies, procedures, and monitoring programs.

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