

## CHAPTER 9

# RADIOACTIVE MATERIALS, CHARACTERISTICS, HAZARDS AND HEALTH CONSIDERATIONS

### 9-1 PLUTONIUM (Pu)

a. General Characteristics. Plutonium is a heavy metal with a shiny appearance (similar to stainless steel) when freshly machined. After exposure to the atmosphere for a short period of time, it will oxidize to a dark brown or black appearance.

b. Radiological Characteristics. The radiological half-lives of the plutonium isotopes and significant daughter products present in a nuclear weapon containing plutonium are as follows:

<u>Isotope</u>	<u>Half-life (years)</u>
<b>Pu-239,</b>	2.41 X 10 <sup>4</sup>
<b>Pu-240</b>	6.57 X 10 <sup>3</sup>
Pu-241	14.4
<b>Pu-242</b>	3.76 X 10 <sup>5</sup>
Am-241	432

(1) All of the isotopes listed above are primarily alpha emitters except Pu-241, which is primarily a beta emitter. Pu-241 is an important consideration because of its daughter product, americium-241 (Am-241).

(2) Weapons grade plutonium (including americium) will emit two detectable photons, a 17 **keV** x-ray and 60 **keV** gamma ray. Surveys plotting the 17 **keV** x-ray data must be done within the **first** five days. After this time, or after rain, the measurable low energy radiation may be shielded as the contaminant migrates into the ground. Am-241 provides the 60 **keV** gamma radiation which is detectable even after such migration. Gamma radiation can be detected at distances of several meters by many survey instruments.

(3) A critical mass can range from several hundred grams, to several thousand grams, depending on the geometry of the container and the material surrounding, or near, the plutonium. Therefore, recovery personnel should consult EOD technical publications and/or coordinate with knowledgeable scientific advisors from the DoE ARG to ensure a critical mass is not being assembled.

c. Hazards and Health Considerations: Plutonium is considered the most significant radiological hazard associated with an accident involving nuclear weapons containing plutonium. The primary hazard of plutonium, an alpha emitter, results from entry into the body by inhalation and subsequent deposition in the lungs. Most of the plutonium that eventually enters the blood stream is deposited in the bone and liver. Bone deposition may produce bone diseases (including cancer) many years later. Because both the physical and biological half-lives of plutonium are extremely long, it will essentially be held within the body for a lifetime. The hazards from americium taken inside the body are comparable to those of plutonium.

(1) The elimination of plutonium from the body is a very slow process. However, if a person is given prompt hospital treatment with a chelating agent, some of the plutonium retained in the body may be reduced significantly.

(2) A properly sized and fitted protective mask and standard anti-contamination clothing will protect personnel against levels of plutonium contamination expected at an accident site.

### 9-2 URANIUM (U)

a. General Characteristics: Uranium is a heavy element which occurs in nature in significant quantities. When first machined, it has the appearance of stainless steel. When exposed to the atmosphere for a short period, it will oxidize to a golden-yellow color and from that to black.

b. Radiological Characteristics: Three forms of uranium have been used in nuclear weapons—natural uranium, depleted uranium, and enriched uranium.

(1) Natural Uranium - When uranium is separated from its ore, the resulting mixture of uranium is referred to as natural uranium.

to as “natural uranium.” Natural uranium consists of the following three alpha-emitting isotopes:

<u>Isotope</u>	<u>Abundance</u>	<u>Half-life (years)</u>
U-238	99.284	4.5 x 10 <sup>9</sup>
U-235	0.710	7.1 x 10 <sup>8</sup>
U-234	0.006	21.5 X 10 <sup>5</sup>

Natural uranium in a metal form has been called “tuballoy”.

(2) Depleted Uranium - Uranium with some amount of its U-235 extracted is known as “depleted uranium” (for example, depleted in U-235). Depleted uranium is called “DU\*” and “D-38”.

(3) Enriched Uranium - “Enriched uranium” is uranium containing more than the naturally--occurring amount of U-235. It is manmade and the enrichment--that is the concentration of the U-235 in the uranium--may vary up to over 90 percent U-235. Enriched uranium has been used as the nuclear material in some weapons and is called “**oralloy**” at certain enrichment percentages (for example, 40 percent and 93 percent). Like plutonium, care must be taken during the recovery of enriched uranium so that a critical mass is not assembled. Depending on the material associated with the uranium and the geometry of the container, a critical mass of enriched uranium can range from several hundred to several thousand grams. Therefore, recovery personnel should consult EOD technical publications and/or coordinate with knowledgeable scientific advisors from the DoE ARG to ensure that a critical mass is not being assembled.

c. Hazards and Health Considerations The radiological hazards associated with any of the isotopes of uranium are less severe generally than those of plutonium. If uranium is taken internally, a type of heavy metal poisoning may occur, and lung contamination due to inhalation can cause a long term hazard. In general, when involved in a fire, uranium will melt and form a slag with only a portion of it oxidizing. However, the possibility of hazardous airborne contamination exists and protective measures must be taken to protect against inhalation or ingestion. An M 17 protective mask and standard anti-contamination clothing will protect personnel adequately against uranium hazards.

### 9-3 TRITIUM (T)

a.. General Characteristics: Tritium is a radioactive isotope of hydrogen and diffuses very rapidly in the air

with a measurable diffusion rate even through very dense materials such as steel. Tritium combines chemically with a number of elements liberating heat in the process, and like normal hydrogen, can combine combustively with air forming water and release great amounts of heat. Metals react with tritium in two ways: by plating (the process by which a thin film of tritium is deposited on the surface of the metal) and by hydriding (the chemical combination of tritium with the metal). In either reaction, the surface of the metal will become contaminated with radioactive material.

b. Radiological Characteristics: Tritium has a radiological half-life of 12.26 years and decays into a stable helium-3 atom by emission of a weak beta particle. With the proper catalyst i.e., fire, tritium combines spontaneously with oxygen in the air and will also replace ordinary hydrogen in water or other hydrogenous material (grease or oil), causing these materials to become radioactive.

c. Hazards and Health Considerations: Tritium constitutes a health hazard when personnel are engaged in specific weapon render-safe procedures, when responding to an accident that has occurred in an enclosed space, and during accidents which have occurred in rain, snow, or in a body of water. In its gaseous state, tritium is not absorbed by the skin to any significant degree. The hazardous nature of tritium is due to its ability to combine with other materials. Tritium water vapor (TO or HTO) is readily absorbed by the body, both through inhalation and absorption through the skin. The radioactive water that enters the body is chemically identical to ordinary water and is distributed throughout the body tissue. Although it takes a relatively large amount of tritium to be a significant radiation hazard, caution should be taken. Tritium which has plated out on a surface or combined chemically with solid materials is a contact hazard. The human body normally eliminates and renews 50 percent of its water in about 8-12 days. This turnover time or biological half-life varies with the fluid intake. Since tritium oxide is water, its residence time in the body may be significantly reduced by increasing the fluid intake. Under medical supervision, the biological half-life may be reduced to about three days. If forced-fluid treatment is deemed necessary, and medical supervision is unavailable, a recommended procedure is to have the patient drink one quart of water within one-half hour after exposure. Thereafter, maintain the body’s water content by imbibing the same amount as that excreted until medical assistance can be obtained. Medical assistance should be obtained as soon as possible.

Although the biological half-life of **tritium** is short, personal hazard results because of the ease with which tritium water vapor is absorbed and its rapid distribution throughout the body tissue. A self-contained breathing apparatus and protective clothing will protect personnel against tritium absorption for short periods of time. A filter mask such as M 17 has no protective value for tritium.

#### 9-4 THORIUM (Th)

a. General Characteristics: Thorium is a heavy, dense gray metal which is about three times as abundant as uranium. Thirteen isotopes are known, with atomic masses ranging from 223 through 235.

b. Radiological Characteristics: Thorium-232 is the principal isotope. It decays by a series of alpha emissions to radium-225, whose radiological half-life of 14.1 billion years. Thorium-232 is not fissionable, but it is used in reactors to produce fissionable uranium-233 by neutron bombardment. A non-nuclear property of thorium is that when heated in air, it glows with a dazzling white light. Because of this property, one of the major uses of thorium has been in the **Welbach** lantern mantel used in portable gas lights. An unburned mantle will provide an alpha indication of approximately 15,000 CPM on

standard alpha survey instruments. Mantle ash from a single mantle will provide even higher readings.

c. Hazards and Health Considerations: Thorium presents both a toxic and radiological hazard. Toxicologically, it causes heavy metal poisoning similar to lead or the uranium isotopes. Biologically, thorium accumulates in the skeletal system where it has a biological half-life of 200 years, the same as plutonium. An M 17 protective mask and standard anti-contamination clothing will adequately protect against thorium.

#### 9-5 FISSION PRODUCTS

The materials considered thus far are used in weapons in pure forms and in combinations with other elements. Due to weapon design, the probability of a nuclear detonation as a result of an accident is unlikely. If fission occurs, the products of the reaction may pose a severe hazard. In general, fission products are beta and gamma emitters and are hazardous, even when external to the body. To predict and estimate the quantity of fission products is difficult since the amount of fission is unknown, and to further complicate the situation, the relative isotopic abundances will change with time as the shorter lived radioisotopes decay. An estimate of the hazard may be obtained by beta and gamma monitoring.