

Radiation at FUSRAP Sites

U.S. Army Corps of Engineers
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Building Strong®

Formerly Utilized Sites Remedial Action Program (FUSRAP)

The Nature of Radiation

Radiation is the emission of energy in the form of waves or particles through space or through a material medium. Radioactivity is the emission of radiation (energy) that occurs when an atom, the basic unit of matter, is unstable and decays into a more stable form.

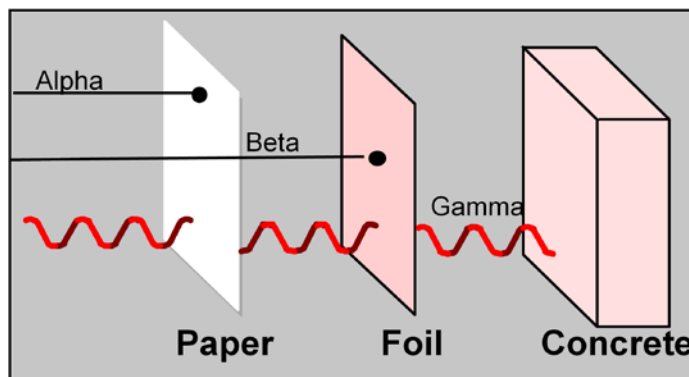
Radiation is classified into two main categories, non-ionizing and ionizing, depending on its ability to ionize matter. Ionization is the process by which an atom or molecule acquires a negative or positive charge by gaining or losing electrons to form ions. At FUSRAP sites the primary focus is on ionizing radiation, which has the ability to ionize matter directly or indirectly.

Directly ionizing radiation particles are particles which carry a charge such as beta or alpha particles and can directly ionize matter. Indirectly ionizing radiation is photons (i.e. gamma rays) or neutrons (neutral particles) which interact with the medium and produce directly ionizing charged particles (i.e. alpha/beta particles) which will then cause ionization.

Alpha particles are large subatomic particles consisting of two protons and two neutrons (identical to a Helium nucleus) which are ejected from the nucleus of some unstable (radioactive) atoms. They can travel only a few inches through air and can be stopped by a sheet of paper or the outer layers of skin. Materials that emit alpha particles are potentially dangerous if they are inhaled or swallowed, but external exposure generally does not pose a danger. These particles are directly ionizing and interact with matter by collisions or through electromagnetic interactions (alpha particles are positively charged).

Beta particles are subatomic particles (equivalent to an electron) that are ejected from the nucleus of some unstable (radioactive) atoms. Beta particles are smaller and faster than alpha particles but can travel further in air. They can easily be stopped by a thin shield such as a sheet of aluminum foil. These particles are directly ionizing and interact with matter by collisions or through electromagnetic interactions (beta particles are negatively charged).

Gamma rays are photons which are emitted from some unstable (radioactive) atoms to rid an unstable nucleus of excess energy after most nuclear reactions. Gamma rays are a type of electromagnetic wave, much like X-rays, and move at the speed of light. Gamma rays do not have a mass or an electric charge and, as a result, penetrate much further through matter than either alpha or beta radiation. These rays can be stopped by a thick shield of lead, steel, or concrete.



Radiation cannot be detected by human senses. For example it cannot be seen, heard, smelled, or tasted. However, it can be detected by instruments specifically designed to measure the type and energy of radiation released during a radioactive decay. Examples of such detectors used at FUSRAP sites include geiger counters, scintillators, gamma spectroscopy detectors and personnel dosimeters.

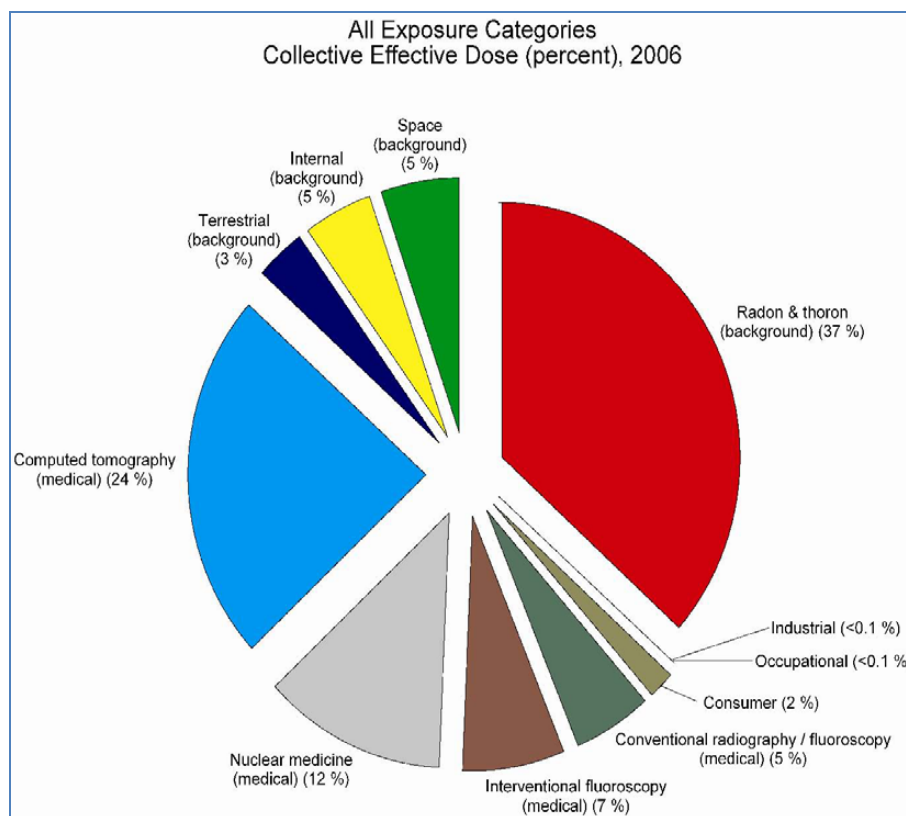
The international unit for radioactivity is the becquerel (Bq) which is defined as one decay or disintegration per second. The traditional unit used in the United States for radioactivity is the curie (Ci) which is defined as 3.7×10^{10} Bq. At FUSRAP sites the concentration of radioactivity in soil (activity/gram) or water (activity/liter) is typically on the order of picocuries per gram (pCi/g) or picocuries per liter (pCi/L) where pico is the prefix denoting a factor of 10^{-12} or one billionth of one curie per gram or liter, respectively. Guidelines for remediation of soil at FUSRAP sites are commonly expressed in units of pCi/g and regulatory limits of radionuclides in drinking water are commonly presented in pCi/L.

The dose equivalent is a measurement of the biological damage to living tissue as a result of exposure to radiation. This measurement is expressed in the international units of sieverts (Sv) and as rems in the traditional units (United States). Regulatory limits of radiation dose to the general public are expressed in millirems (thousandths of a rem), abbreviated as mrem.

Sources of Radiation

Radiation is naturally occurring and is found in all aspects of our daily lives. Sources of natural radiation include radionuclides in soil (e.g., uranium-238), cosmic radiation, and radioactivity in the food we eat (e.g., carbon-14 and potassium-40). There are also man-made sources of radiation for such as medical diagnostics (e.g., X-rays and fluoroscopy procedures) as well as nuclear medicine procedures.

The National Council of Radiation Protection (NCRP) has determined that the average U.S. resident receives an dose of 620 mrem per year. The exposure a member of the general public can receive as a result of radiation from FUSRAP sites is very low. The maximum allowable exposure is 100 mrem per year above background levels. The following chart, generated by the NCRP, provides a summary of the sources of exposure which lead to this annual background as a reference.



Average annual dose distribution in the U.S. [Total dose received is 620mrem/year].
Reference: National Council on Radiation Protection - Report 160 (2009)

Radioactive Materials at FUSRAP Sites

The Formerly Utilized Sites Remedial Action Program (FUSRAP) was initiated in 1974 to identify, investigate, and if necessary, clean up or control sites throughout the United States contaminated as a result of Manhattan Engineer District (MED) or early Atomic Energy Commission (AEC) activities. Both the MED and the AEC were predecessors of the U.S. Department of Energy (DOE). In October 1997, Congress transferred FUSRAP to the U.S. Army Corps of Engineers. Several sites with radioactive contamination similar to that produced by MED or AEC activities have also been added to FUSRAP by Congress.

FUSRAP was established to ensure that the public and the environment are not exposed to potentially harmful levels of radiation from these sites. The goal of FUSRAP is to clean up or contain the radioactive material so that the sites may be released for appropriate future use. FUSRAP sites are generally contaminated with low levels of uranium, thorium and radium, and their associated decay products (these decay series emit alpha, beta and gamma radiation). Mixed wastes are sometimes present, such as chemical contamination comingled with radiologically impacted soil.

It is important to understand that the radioactive materials left at FUSRAP sites are contaminated with low levels of residual radioactivity since the raw product was shipped off site at the time. In most cases, the contaminants on a FUSRAP site currently pose no risk above acceptable limits to human health or the environment given their current land uses. At many

FUSRAP sites, the contamination is in soil that is several inches below ground level, capped with vegetation and/or is in areas that have restricted access to the general public.

Many FUSRAP sites have environmental monitoring programs which take into account potential pathways of exposure that may negatively affect human health or the environment. Examples of environmental media that may be sampled at a FUSRAP site could include some or all of the following: surface water, sediment, groundwater, ambient air (radon) and external gamma radiation.

Even though FUSRAP sites may contain levels of radioactivity above current regulatory guidelines, none of the sites pose an immediate health risk to the public or environment given the current use of the sites. Although these materials are not currently a hazard, they will remain radioactive for thousands of years, and health risks could increase if the use of the site were to change. The Corps of Engineers wants to ensure that each site is protective to a standard that considers possible future uses for the land.

FUSRAP Process

The Corps of Engineers implements FUSRAP subject to the administrative, procedural, and regulatory provisions of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan. The first step is to determine the levels of radioactivity at the site. Air, water, soil, or other routes by which radioactive materials could spread are identified and monitored. Potential human health and ecological risks from the contaminants are assessed. At many sites, access restrictions minimize exposure of the public to radioactive materials. If necessary, remedial response alternatives are developed and evaluated and a preferred remedial alternative is identified. Comments received from the community are considered regarding the preferred alternative. A record of decision documents the selected remedial alternative.