Radiation and How it affects you

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INTRODUCTION

Radioactivity is the emission of radiation from an unstable atomic nucleus. This emission of energy is called radioactiv decay. The radiation can be emitted in the form of a positively charged alpha particle (a), a negatively charged beta particle (ß), or gamma rays (?).

An additional radioactive process is nuclear fission, where some elements can split as a result of absorbing an additional neutron. Such unstable, or fissile, isotopes include uranium-235 and plutonium-239. These are the isotopes used in nuclear reators and nuclear weapons. When a nucleus splits there are three ways in which the energy is released: radiation, neutrons (usually two or three), and two new smaller nuclei (usually referred to as fission products).

Radiation is often separated into two categories, ionizing and non-ionizing, to denote the energy and danger of the radiation. Ionization is the process of removing electrons from atoms, leaving two electrically charged particles (ions) behind. Some forms of radiation like visible light, microwaves, or radio waves do not have sufficient energy to remove electrons from atoms and hence, are called non-ionizing radiation. The negatively charged electrons and positively charged nuclei created by ionizing radiation may cause damage in living tissue. The term *radioactivity* generally refers to the release of ionizing radiation.

SOURCES OF RADIATION

Natural Background Radiation - The earth and all living things on it are constantly bombarded by radiation from space, similar to a steady drizzle of rain. Charged particles from the sun and stars interact with the earth's atmosphere and magnetic field to produce a shower of radiation, typically beta and gamma radiation. The dose from **cosmic radiation** varies in different parts of the world due to differences in elevation and the effects of the earth's magnetic field.

Radioactive material is found throughout nature. It occurs naturally in the soil, water, and vegetation. The major isotopes of concern for terrestrial radiation are uranium and the decay products of uranium, such as thorium, radium and radon. Low levels of uranium, thorium, and their decay products are found everywhere. Some of these materials are ingested with food and water, while others, such as radon, are inhaled. The dose from terrestrial sources varies in different parts of the world. Locations with higher concentrations of uranium and thorium in their soil have higher dose levels.

In addition to the cosmic and terrestrial sources, all people also have radioactive potassium-40, carbon-14, lead-210, and other isotopes inside their bodies from birth. The variation in dose from one person to another is not as great as the variation in dose from cosmic and terrestrial sources.

Man-Made Radiation Sources - The average exposure for a person is about 360 millirems/year, 81 percent of which comes from natural sources of radiation. The remaining 19 percent results from exposure to man made radiation sources. By far, the most significant source of man-made radiation exposure to the general public is from medical procedures, such as diagnostic X-rays, nuclear medicine, and radiation therapy. Some of the major isotopes are I-131, Tc-99m, Co-60, Ir-192, Cs-137, and others.

In addition, members of the public are exposed to radiation from consumer products, such as tobacco (polonium-210), building materials, combustible fuels (gas, coal, etc.), ophthalmic glass, televisions, luminous watches and dials (tritium), airport X-ray systems, smoke detectors (americium), road construction materials, electron tubes, fluorescent lamp starters, lantern mantles (thorium), etc.

Of lesser magnitude, members of the public are exposed to radiation from the nuclear fuel cycle, which includes the entire sequence from mining and milling of uranium to the disposal of the used (spent) fuel. The substances involved are uranium and its daughter products.

Occupationally exposed individuals are exposed according

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to their occupations and to the sources with which they work. The exposure of these individuals to radiation is carefully monitored with the use of tiny instruments called dosimeters. Some of the isotopes of concern are cobolt-60, cesium-137, americium-241, and others. Examples of industries where occupational exposure is a concern include:

Fuel cycle

Industrial Radiography

Radiology Departments (Medical)

Radiation Oncology Departments

Nuclear power plant

Nuclear medicine Departments

National (government) and university Research Laboratories

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.

THE EFFECTS OF RADIATION ON PEOPLE

We tend to think of biological effects of radiation in terms of their effect on living cells. For low levels of radiation exposure, the biological effects are so small they may not be detected. The body has defense mechanisms against many types of damage induced by radiation as well as by chemical carcinogens. Consequently, biological effects of radiation on living cells may result in three outcomes:

injured or damaged cells repair themselves, resulting in no residual damage

cells die, much like millions of body cells do every day, being replaced through normal biological processes

cells incorrectly repair themselves resulting in a biophysical change.

The associations between radiation exposure and the development of cancer are mostly based on populations exposed to relatively high levels of ionizing radiation (e.g., Japanese atomic bomb survivors, and recipients of selected diagnostic or therapeutic medical procedures). Cancers associated with high dose exposure include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma, and stomach cancers. Department of Health and Human Services literature also suggests a possible association between ionizing radiation exposure and prostate, nasal cavity/sinuses, pharyngeal and laryngeal, and pancreatic cancer.

The period of time between radiation exposure and the detection of cancer is known as the latent period. Those cancers that may develop as a result of radiation exposure are indistinguishable from those that occur naturally or as a result of exposure to other chemical carcinogens. Furthermore, National Cancer Institute literature indicates that other chemical and physical hazards and lifestyle factors (e.g., smoking, alcohol consumption, and diet) significantly contribute to many of these same diseases.

Although radiation may cause cancer at high doses and high dose rates, public health data do not unequivocally establish the occurrence of cancer following exposure to low doses and dose rates -- below about 10,000 mrem (100 mSv). Studies of occupational workers exposed to chronic low-levels of radiation above normal background have shown no adverse biological effects. Even so, the radiation protection community conservatively assumes that any amount of radiation may pose some risk for causing cancer and hereditary effect, and that the risk is higher for higher radiation exposures. A linear, no-threshold (LNT) dose response relationship is used to describe the relationship between radiation dose and the occurrence of cancer. This dose-response model suggests that any increase in dose, no matter how small, results in an incremental increase in risk. The LNT hypothesis is accepted by the NRC as a conservative model for estimating radiation risk.

High radiation doses tend to kill cells, while low doses tend to damage or alter the genetic code (DNA) of irradiated cells. High doses can kill so many cells that tissues and organs are damaged immediately. This in turn may cause a rapid whole body response often called Acute Radiation Syndrome. The higher the radiation dose, the sooner the effects of radiation will appear, and the higher the probability of death. This syndrome was observed in many atomic bomb survivors in 1945 and emergency workers responding to the 1986 Chernobyl nuclear power plant accident. Approximately 134 plant workers and firefighters battling the fire at the Chernobyl power plant received high radiation doses (70,000 to 1,340,000 mrem or 700 to 13,400 mSv) and suffered from acute radiation sickness. Of these, 28 died from their radiation injuries.

MINIMIZING EXPOSURE TO RADIATION

Although exposure to ionizing radiation carries a risk, it is impossible to completely avoid exposure. Radiation has always been present in the environment and in our bodies. We can, however, avoid undue exposure.

There is a range of simple, sensitive instruments capable of detecting minute amounts of radiation from natural and man-made sources. Radiation is very easily detected. In addition, there are four ways in which we can protect ourselves:

Time: For people who are exposed to radiation in addition to natural background radiation, limiting or minimizing the exposure time will reduce the dose from the radiation source.

Distance: In the same way that the heat from a fire is less intense the further away you are, so the intensity of the radiation decreases the further you are form the source of the radiation. The dose decreases dramatically as you increase your distance from the source.

Shielding: Barriers of lead, concrete, or water give good protection from penetrating radiation such as gamma rays and neutrons. This is why certain radioactive materials are stored or handled under water or by remote control in rooms constructed of thick concrete or lined with lead. There are special plastic shields which stop beta particles and air will stop alpha particles. Inserting the proper shield between you and the radiation source will greatly reduce or eliminate the extra radiation dose.

Containment: Radioactive materials are confined in the smallest possible space and kept out of the environment. Radioactive isotopes for medical use, for example, are dispensed in closed handling facilities, while nuclear reactors operate within closed systems with multiple barriers which keep the radioactive materials contained. Rooms have a reduced air pressure so that any leaks occur into the room and not out of it.

Natural and artificial radiations are not different in any kind or effect. Above the background level of radiation exposure, the NRC requires that its licensees limit maximum radiation exposure to individual members of the public to 100 mrem (1 mSv) per year, and limit occupational radiation exposure to adults working with radioactive material to 5,000 mrem (50 mSv) per year.

Measuring Radiation

DOE WORKER PROTECTION

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 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 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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