APPENDIX B

RADIOLOGICAL HAZARDS AND THEIR CONTROL

B- I. Types of ionizing radiation

At any facility which produces, processes, uses, or stores radioactive materials, radiological hazards will be present to some degree. The basic hazard associated with radioactive material is the emission of ionizing radiation. Radioactive material, whether naturally occurring or manmade, is unstable and is constantly seeking a stable, atomic configuration through a process called radioactive decay. As radioactive material decays to stable, nonradioactive material, or to other types of radioactive material, ionizing radiation is emitted. This ionizing radiation will be emitted in either particle or electromagnetic waveform. The four basic types of radiation of concern are alpha radiation (particles), beta radiation (particles), gamma radiation (electromagnetic waves), and neutron radiation (particles).

a. Alpha Radiation. Alpha radiation is composed of positively charged particles. Each particle is composed of two neutrons and two protons, making an alpha particle identical to the nucleus of a helium atom (2^4He). Alpha radiation is less penetrating than either beta or gamma radiation and may be completely stopped by a sheet of paper. Alpha radiation is not a hazard external to the body but becomes a hazard if the alpha-emitting radioactive material gets inside the body. Alpha radiation is denoted by the Greek letter a.

b. Beta Radiation. Beta radiation is composed of negatively charged particles. Each particle is identical to an electron (-1^0e). Beta radiation is more penetrating than alpha but less penetrating than gamma radiation and may be completely stopped by a thin sheet of metal such as aluminum. Beta radiation is an external hazard to the skin of the body and to the eyes, and is also an internal hazard if the beta-emitting radioactive material gets inside the body. Beta radiation is denoted by the Greek letter β.

c. Gamma Radiation. Gamma radiation is high energy, short wavelength electromagnetic radiation, frequently accompanying alpha and beta radiation. Gamma radiation is much more penetrating than either alpha or beta radiation because of its wave form. Gamma is similar in form and energy to K-radiation. Gamma radiation is not entirely stopped by materials but can be almost completely attenuated by dense materials like lead or depleted uranium, and with greater thicknesses of materials such as water or concrete. Because of its penetrating power, gamma radiation is a hazard to the entire body, whether or not the gamma emitting radioactive material is inside or outside the body. Gamma radiation is denoted by the Greek letter γ.

d. Neutron Radiation. Neutron radiation is composed of particles with no electrical charge (1^0n). Neutron radiation is less penetrating than gamma radiation, but more penetrating than either alpha or beta radiation and may be completely stopped by an appropriate thickness of a hydrogenous material like water or concrete. Neutron radiation has the unique property of being able to convert nonradioactive material to radioactive material. Neutrons are external hazards. They are emitted by machines such as nuclear reactors. They could be an internal hazard if a source emitting neutrons enter the body. Neutron radiation is denoted by the small English letter n.

B-2. Types of radiological hazards

The radiations described above are hazards because each has the ability to ionize, either directly or indirectly, cells which make up body organs and structures. This exposure can be either internal or external. If the body is exposed to large doses of ionizing radiation, cell damage may be sufficient to interfere with normal body functions and can cause undesirable biological effects, both in the individuals exposed and in the future offspring of these individuals. During the decommissioning process, radiological hazards may be present in the form of radiation only, or in the form of radiation together with the radioactive material emitting the radiation. These hazards may be grouped as external radiation, surface radioactive contamination, airborne radioactive contamination and waterborne radioactive contamination.

a. External Radiation. External radiation hazards to an individual are those presented by exposure to emissions from radioactive sources and contaminants that are external to the person. External radiation can be emitted from contained or partially contained sources. Examples include sealed radioactive sources and radioactive material contained in a closure such as a pipe, equipment, or a system component of some type. External radiation hazards may also be posed by surface contamination, airborne contamination, or waterborne contamination. Radiation dose to individuals must be measured to show compliance with regulatory limits. This measurement is accomplished by film badges, thermoluminescent dosimeters (TLDs). direct-reading dosimeters, or a combination of the three. Radiation dose rates are measured by portable and fixed instruments to quantify the external radiation hazard. Individuals may be protected from external radiation, or at least have their radiation dose minimized, by three methods: time, distance, and shielding.

(1) Time. Minimizing time spent in areas where external radiation is present minimizes radiation dose.

(2) Distance. The greater the distance from a source of radiation, the less the dose rate.

(3) Shielding. Installing materials such as lead or concrete around a source of radiation will reduce the dose rate.

b. Surface Radioactive Contamination. Surface contamination occurs in two basic forms: fixed and removable. Fixed contamination is that which tightly adhered to a surface. The hazard is from radioactive material emissions. Removable contamination is readily spreadable. It poses an external hazard through exposure to its emissions and is available to be taken inside an individual by ingestion, inhalation, through the skin, or through open wounds. Surface contamination can be caused in many ways; for example, opening a system containing radioactive material for maintenance, leakage from a sealed source, or an accidental spill of radioactive material during a process of some type. It can also be transported from contaminated to uncontaminated areas by the movement of individuals and equipment or by air movement through the HVAC system. Protection and removal procedures are as follows:

(1) Individuals are protected against skin contamination by removable surface contamination through the use of protective clothing which protects from head to foot. This clothing is removed before leaving a contaminated area, thus preventing the spread of surface contamination.

(2) Any items removed from a contaminated area are put in appropriate containers to prevent the spread of contamination.

(3) Removable surface radioactive contamination can be removed from walls, floors, items, even skin much in the same manner that dirt is removed from these surfaces, by the use of soap and water and other routine cleaning techniques.

(4) Fixed contamination can be dislodged from a surface and become removable contamination by processes such as scrubbing a surface with a wire brush, filing on the surface, flame cutting, welding, and grinding.

c. Airborne Radioactive Contamination. Airborne contamination may result from several situations; for ex ample, disturbing surface contamination by walking through a contaminated area or working in a contaminated area, performing an operation such as welding or grinding on a contaminated surface, or the release of radioactive material from a system during operation. Airborne contamination is usually only a minor external radiation hazard but can pose a serious internal radiation hazard because the contamination is easily inhaled by an individual.

(1) Individuals are protected against the inhalation of airborne contamination by the use of respiratory protective equipment. This equipment may be a filter respirator or an air-supplied respirator depending on the concentration of radioactive material in the air.

(2) Airborne contamination can be minimized, or prevented, by the use of ventilation through filtration and by performing airborne producing operations in contained areas.

d. Waterborne Radioactive Contamination. Waterborne contamination may result from such sources as leaks from systems containing contaminated water and water used for surface decontamination. If contaminated water dries, surface contamination results. Waterborne contamination is usually only a minor external radiation hazard but can pose a more serious internal radiation hazard if the water is ingested.

(1) Individuals are protected against waterborne contamination by the use of plastic clothing and, if necessary, respiratory protective equipment.

(2) Contaminated water must be handled and disposed of in a controlled manner.