Bremsstrahlung Safety Considerations

FACT SHEET 26-011-0915

Bremsstrahlung, German for braking radiation, is emitted when a charged particle experiences a change in velocity and releases a photon.

This fact sheet will restrict itself to the most commonly encountered cases of bremsstrahlung produced by beta-emitting nuclides and x-ray machines.

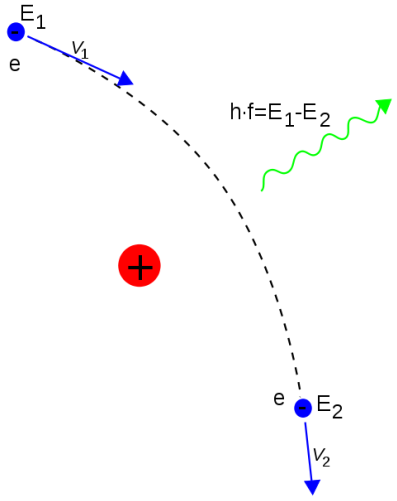

Figure 1. Illustration of bremsstrahlung production

Mechanism of production

Energetic charged particles, whatever their source, interact through electromagnetic forces with atoms. As a charged particle passes near a nucleus, its speed and/or direction may change rapidly due to the electrostatic force. This change in velocity means the charged particle is experiencing acceleration, and an accelerating charged particle releases radiation. Figure 1 depicts the production of a bremsstrahlung photon from the interaction between an electron and a nucleus. The resulting bremsstrahlung photon has energy equal to the difference between the electron's energy before and after the interaction.

The radiation released is in the form of photons with a continuous spectrum of energies that extend as high as the initial charged particle's energy. Bremsstrahlung production is more likely for high energy charged particles and high atomic number (Z) materials. This is significant for shielding and safety considerations related to beta-emitting nuclides and x-ray machines.

Sources of bremsstrahlung

Three commonly encountered sources of bremsstrahlung are beta-emitting nuclides, x-ray machines, and high-voltage electronic equipment. Beta-emitting nuclides release high-energy electrons or positrons as their nucleus attempts to reach a more stable configuration. These charged particles interact with shielding materials to produce bremsstrahlung photons. These nuclides are used in a wide variety of medical, industrial, and research contexts.

X-ray machines use a high voltage to accelerate electrons across a vacuum tube. The accelerated electrons collide with a metal target, producing bremsstrahlung photons. While x-ray machines do not emit radiation when power is off, radionuclides continuously emit radiation, and the associated hazard must be controlled.

Electrons produced in high-voltage electronic equipment can be accelerated to energies where bremsstrahlung production can be significant.

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Radiation protection considerations

An understanding of bremsstrahlung is essential to the responsible use of x-ray machines and beta-emitting nuclides. High Z material, such as lead, is ideal for absorbing and blocking photon radiation, but it is generally not appropriate as the only shield for charged particles due to the potential for bremsstrahlung. For relatively low energies or small quantities it may be sufficient to shield with a low Z shield such as a sheet of plastic. For higher energies or greater quantities it may be necessary to use two layers of shielding, a layer of low Z material thick enough to completely attenuate the energetic electrons, followed by a high Z material to absorb any bremsstrahlung produced in the low Z shield. Acceptable shielding configurations are illustrated in Figure 2.

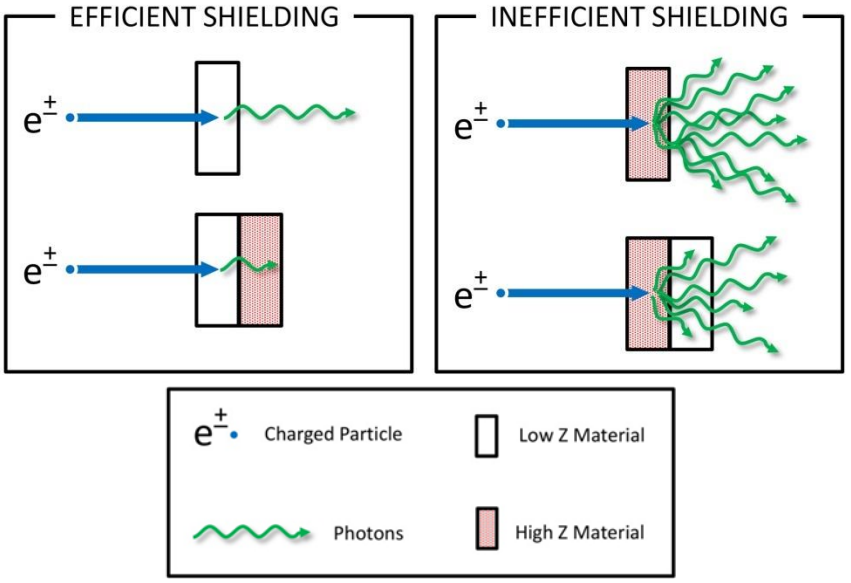

Figure 2. Examples of Acceptable and Unacceptable Methods for shielding sources of energetic electrons

References and further reading

Berger, M.J., Selzer S.M. 1983, *Stopping Powers and Ranges of Electrons and Positrons,* NBSIR 82-2550A, National Bureau of Standards, Washington D.C.

Martin, James E. 2006, *Physics for Radiation Protection,* Wiley-VCH, Weinheim.

Turner, James E. 2007, *Atoms, Radiation, and Radiation Protection*, Wiley-VCH, Weinheim.