

Their principal interest lies in their short necessary processing time since the electron beam quickly provides an important dose to the product to be sterilized due to its very high dose rate. However, their very weak penetrating capacity constrained to irradiate limited surface mass ($<8 \text{ g/cm}^2$, i.e., 8 cm in density 1 material) products packaged in cardboard boxes.

With the development of medium energy, self-shielded accelerators, electron beam sterilization can also be processed in a different way. Products can be treated piece by piece. This provides the advantage to require lower energy level (a few MeV) and as a matter of fact cheaper accelerators with cheaper shielding. The high-throughput rates are well suited to a just-in-time supply process or to full integration in the production line. In-line sterilization tunnels using electron beams have become a reality since the development of low and medium energy accelerators small enough to fit into self-shielded units for integration in production lines. They provide fast continuous room temperature sterilization that is simple to validate and traceable. The economies are apparent in terms of time, logistics, fixed assets costs, labor costs, etc. Environmental impact is considered low.

Electromagnetic Radiations

γ -Radiation

The very large majority of the treatments by electromagnetic radiations are thus carried out currently using γ rays emitted by radioactive sources, primarily cobalt-60. It is produced by neutron bombardment in a nuclear reactor of the metal cobalt-59, and then doubly encapsulated in stainless steel pencils to prevent any leakage during its use in an irradiator. This radioelement emits two γ rays (1.17 and 1.33 MeV) and has a period of 5.27 years (time after which the emitted radiation quantity decreases by half). The implementation of this type of treatment is based on the exposure of the product during a given time, with the radiation emitted by the radioactive source.

γ -Sources require important installations and moreover require managing the radioactive waste problem because the radioactive sources are changed before they are completely stable. However, because of its low attenuation inside the treated material, this type of radiation makes it possible to sterilize important volumes of products, packaged onto pallets.

X Rays

X-ray electromagnetic radiation (Bremsstrahlung radiation) is generated by the electron beams absorbed by a heavy metal target (generally out of tungsten or tantalum). Contrary to the γ rays, the X rays are mainly concentrated in the direction of the incidental electron beam, toward the products to be treated.

This type of treatment is currently little used in industry and is limited of principle by poor conversion yield of the electrons into X rays.

However, with the development of a new generation of high-energy, high-power electron accelerators (Rhodotron), X rays seem to be an interesting combination of the two other processes, that is, electron beam and γ .

X rays have a similar or even higher penetration capacity than γ rays while profiting from a sizeable dose rate inherited from the high-power accelerated electrons (10).