MediZap
Advanced Sterilization

The X-Ray Factor: The Advantages of X-Ray Terminal Sterilization on Sterile Drug Products

Using ionizing radiation for sterile compounded drug irradiation includes Gamma, X-Rays, and electron beams (E-Beams). Gamma-Rays and X-Rays were discovered in the 1890s, and subsequent research has shown that these types of irradiations can effectively kill bacteria. While X-Ray technology has been available for several years, the first commercial facility designed explicitly for sterilization was not opened until 2010. More and more X-Ray irradiators are being installed to sterilize healthcare products. X-Ray sterilization combines the best features of E-Beam and Gamma techniques, offering speedy turnaround times, good processing flexibility, pallet setup processing, and relatively low dose ratios.

The international recognition and wide use of radiation sterilization for the processing of pharmaceuticals, tissues, and biologics is well established. Since the 1950s, radiation sterilization has continued to gain significant market share due to its processing speed, parametric release, and cost competitiveness. The two sterilization techniques used by sterile drug manufacturers, X-Ray, and electron beam, are now widely accepted by regulatory agencies worldwide. Although X-Ray sterilization is not as well-known as the other two methods, it combines the best of both worlds by providing short electronic beam lead times and processing flexibility, along with Gamma pallet configuration processing and relatively low dose rates.

The use of X-Rays in terminal sterilization offers many advantages. For instance, X-Ray terminal sterilization provides better penetration characteristics than Gamma-Rays or E-Beam. While E-Beam can be used for sterilizing low-density and evenly packaged products that do not have challenging geometries, it has limited capacity in liquids and high-density drug products. X-Ray terminal sterilization is well suited for processing drug products in dense configurations.

Moreover, the effects of X-Ray processing are comparable to those of E-Beam terminal sterilization, and the combination of shorter exposure times and improved dose uniformity ratio (DUR) enables customers to apply X-Ray sterilization technology.

X-Ray technology is accepted as an alternative to Gamma and E-Beam methods in international standards, including ISO 13485 (quality management system standards for medical devices) and ISO 11137 series (Sterilization of Healthcare Products—Radiation), GMP, and FDA guidelines. Research has shown that the microbicidal effectiveness is not significantly different when treated with either Gamma rays or X-Rays conditions.

Ionizing radiation, such as X-Rays and E-Beam, is commonly used for terminal sterilization to reduce the microbial bioburden of many different types of sterile drug products such as aqueous solutions, serums, powders, lyophilized powders, pre-filled syringes, ophthalmic droppers, ampules, mini IV bags, and IV bags. Due to the penetrating properties of ionizing radiation and their ability to inactivate microorganisms, X-Rays effectively kill many Gram-negative bacteria such as E. coli, Salmonella, and P. aeruginosa. Results also showed that X-Rays of lower energies were effective in inactivating bacterial spores.

Irradiation is also a standard sterilization method for connective tissue allografts such as skin, cartilage, bone, tendons, heart valves, and corneas. A significant concern for tissue allografts is the risk of disease transmission to the recipient. Hazardous microorganisms may be of donor origin or have been transferred during tissue procurement, processing, storage, and tissue handling. To reduce the possibility of bacterial, fungal, or viral disease transmission, tissue samples must be sterilized before introduction to the potential transplant recipient.

Due to the increasing regulatory demands governing Gamma use and supply chain costs, the use of Cobalt 60 as a radiation source for Gamma irradiation poses a potential risk of radioactivity, making it less attractive for sterile drug applications. The adoption of E-Beam or X-Ray radiation alternatives for sterile drug products has increased due to these factors.

However, despite the acceptability of E-Beam and X-Ray sterilization in regulations and standards, the adoption of these methods has been hindered by knowledge gaps, process limitations, and a lack of expertise. This is a critical issue as the health and safety of patients and consumers of compounded/manufactured sterile drug products are directly affected by the effectiveness of sterilization techniques.

In conclusion, X-Ray processing offers several advantages, including improved penetration and dose uniformity ratio, regulatory approvals and validations, and its ability to sterilize dense configurations of drug products. As knowledge and understanding of this technology improve, it will likely become the preferred sterilization method for many sterile compounded drug products with higher densities that E-Beam technology cannot penetrate.

MediZap offers advanced terminal sterilization by E-Beam and will have new X-Ray technology available for validation and ongoing sterilization with certification of Lewisville, TX SteriTek facility.