

# Understanding the Key Radiation Processing Parameters - A Guide for Food Producers

Since the USDA approved the irradiation of red meat in February 2000, American meat producers have been conducting market trials of hamburger and ground beef and looking hard at the strengths and weaknesses of the available radiation processing technologies. In comparing the performance of gamma, electron beam and X-ray technologies an understanding of the unfamiliar concepts of source activity, energy and power; dose rate and dose homogeneity is helpful.

## Radiation Processing Speed

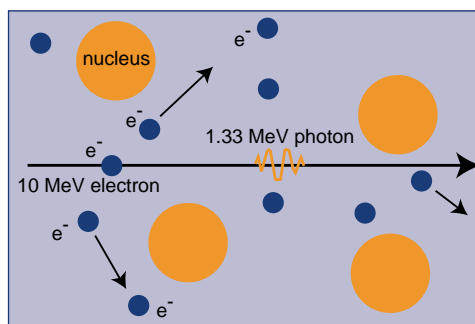
Processing speed is determined by the source power, product density and the minimum dose requirement; increase the product density or the dose requirement and the throughput falls. Gamma sources are specified in terms of their activity measured in curies (Ci). One million curies, (1 MCi) is a moderate size source. Curies can be converted into an equivalent kW power using the rule of thumb below. E-beam and X-ray sources are specified by beam-power; 25 - 50 kW is typical for food applications.

## Useful rules of thumb

- 1 MCi  $\approx$  15 kW of power
- 1 kWhr @ 100% efficiency  $\approx$  3600 kGy kg
- 1 kGy  $\approx$  1 kJ per kg
- 4 kGy will raise product temperature by approx. 1°C

## Penetration Depth

Gamma and X-ray sources emit packets of energy called photons. Cobalt photons have an energy fixed by nature at 1.33 million electron volts (MeV). X-rays



and E-beams can be generated with almost any energy; 5 and 10 MeV are the respective legal maxima applied to food irradiation. The diagram illustrates how an electron beam and a gamma or X-ray photon transfer energy to the product by colliding with the electrons in the food atoms. Having mass and electronic charge, the electron beam rapidly loses energy in collisions near the surface of the product. This limits the treatment thickness of the product to a few centimetres. Gamma and X-ray photons have no mass and no charge and travel further into the product losing energy gradually as they go.

## Absorbed Dose

Absorbed dose is the energy absorbed per unit weight of product, measured in gray (Gy). A few thousand gray (kGy) is a typical dose for food. The cascade of secondary electrons caused by an E-beam produces high dose near the surface of the product. Gamma and X-ray give a much more homogeneous dose that falls gradually with penetration depth.

## Dose Rate

Dose rate is the energy absorbed per unit weight of product per unit time. It is proportional to the number of photons or electrons per unit area i.e. radiation flux density or current. A representative dose rate for gamma is kGy per hour compared with kGy per second for E-beam and X-ray. This is due to the differences in the spatial distribution of energy from equivalent power rated sources. A 15 kW E-beam can be highly focussed into a few square centimetres. A 1 MCi gamma source radiates in all directions.

Comparison of typical processing parameters			
	Gamma	X-Ray	E-Beam
Typical Source Power	3.5 MCi	25 kW	35 kW
Typical Processing Speed*	12 tonnes/Hr @ 4 kGy	10 tonnes/Hr @ 4 kGy	10 tonnes/Hr @ 4 kGy
Source Energy	1.33 MeV	5 MeV	5 - 10 MeV
Penetration Depth **	80 - 100 cm	80 - 100 cm	8 - 10 cm
Dose Homogeneity	High	High	Low
Dose Rate	Low	High	Higher
Best Application	Bulk processing of large boxes or palletised product in shipping cartons in a warehouse environment	Bulk processing of large boxes or palletised product in shipping cartons in a warehouse environment	Sequential processing of primary or secondary packaged product in-line or at-line

We listen. We respond.

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