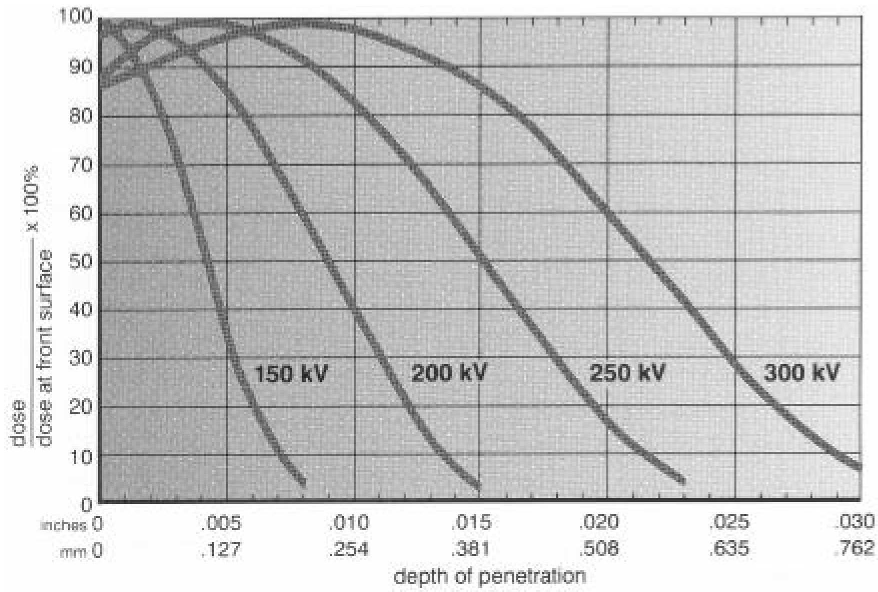
# Electron Beam Energy Transfer




*Normalized dose vs. deptb for a material witb mass density p 1. 0 g/cm-3. The incident electron beam bas passed tbrougb a 0. 0006 incb 015 mm) tbick titaniumfoil and 1.25 incbes (31.75 mm) of air*

The transfer of energy from the electron beam into material is specified completely by four parameters:

- Absorbed dose
- Depth of penetration
- Uniformity
- Throughput

### Absorbed Dose

Absorbed dose is defined as the amount of energy deposited into a specified mass of material. The unit of absorbed dose is the kilogray, defined as the number of joules (J) of energy deposited into I kilogram (kg) of matter. An older, but frequently used unit, is the megarad (Mrad).

1 kGy = 1 kJ/kg

1 Mrad = 10 kGy = 10 kJ/kg

At a fixed electron accelerating voltage, the dose is directly proportional to the electron beam current. Typical values of the dose needed for practical applications are:

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|---|---|
| Drying/curing of inks and coatings | 15-30 kGy |
| Crosslinking of plastic film | 25-150 kGy |
| Sterilization of medical products | 7.5-35 kGy |

### Depth of Penetration

Penetrating power of the electron beam is related to the accelerating voltage and the density of the processed material. Higher voltage causes deeper penetration, and denser material reduces the depth of penetration. The Depth Dose Curves shown in the figure are convenient aids for estimating the penetration depth. These curves relate the dose, normalized to the dose received by the surface of the product, to the depth of penetration in a material with mass density equal to that of water, i.e. p = I g/CM3. Penetration into materials of different density can be estimated by mulitplying the penetration depth, found from the normalized curves, by the ratio of the density of water to the density of the material. For example, a 200 kV beam will have a 50 percent dose point at 0.009 inches (.228 mm) in water and at 0.0045 inches (0.114 mm) in a material twice as dense (p = 2 gm/cm$^3$).

**Dose Uniformity**

Dose uniformity is a direct function of the electron beam uniformity. It is specified as a percentage deviation from the average value, e.g. 20 kGy ± 10%. In general, BroadBeam® processors provide uniformity between ± 10% and ± 5%; many applications can tolerate variations of ± 20% or more.

**Throughput**

Throughput is a measure of the energy deposition rate and relates directly to the amount of material that can be processed within a given time interval. It is measured in kilogray-meters per minute, abbreviated kGyMPM, megarad-feet per minute (MRFPM) or megarad-meters per minute (MRMPM). A BroadBeam® processor rated at 3,000 MRFPM can provide a dose of 3 Mrad when the web speed is 1,000 fpm, or 5 Mrad at 600 fpm, etc. The processor automatically adjusts the beam intensity as the web speed changes so that the dose remains constant.