Applications Note:

Establishing Application Dose Efficiency for AEB Low Energy Electron Beam Systems

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Purpose

This application note is intended for use by AEB customers in order for them to establish process parameters for their low voltage electron beam to meet their dose delivery requirements.

Application

This application note may be applied to AEB 250 and 400mm emitter products that are embedded in either an AEB system or a custom system.

Safety

Please follow all normal safety measures associated with the operation of electron beam systems.

If You Need Assistance

Please contact AEB Applications Support at inquiries@aeb.com if you have questions about this document.

Introduction

The results of electron beam irradiation on both the material properties (chemical, electrical and mechanical) and the efficacy of sterilization depend strongly on the quantity of electron dose that a product receives. Accordingly, it is important for electron beam users to understand how to establish appropriate operating parameters in order to deliver the appropriate level of absorbed dose required for their applications.

Total absorbed electron dose is a function of the complete set of processing parameters, including: electron accelerating voltage (V); emitter-to-sample distance (*a.k.a.* "air gap", T) and ambient gas species (air, nitrogen, other); emission efficiency (ε); speed of material or object exposed to electron beam (S); and electron beam current (I). For practical purposes the effects of voltage, air gap, ambient gas species, and emitter efficiency are combined into one factor that is called the application efficiency (K). The electron beam system controller uses K and S to calculate the beam current that is needed in order to deliver the designated absorbed dose.

AEB measures emitter efficiency, under standard conditions, as part of its manufacturing control processes and provides this number with each electron beam emitter. However, the true application efficiency, K, must be determined by the end user for his/her specific operating conditions. In general, dose measurement is performed first using the end user's specific fixed operating accelerating voltage, air gap and ambient gas. The application K of the emitter can be derived from the relationship between measured absorbed dose and the electron beam operating parameters. This document describes this correlation and the procedure for determining K.

Correlation of Dose to Electron Beam Process Parameters

For the fixed operating conditions of voltage, ambient gas species, and air gap, the absorbed dose (D) can be calculated using these parameters, as expressed in an equation (1).

$$D = \frac{K * I}{S} \qquad (1)$$

Typical Units for these parameters are: D, kGy; I, mA; S, ft/min; and K, kGy ft/min/mA.

As can be seen in equation (1), absorbed dose linearly depends on application efficiency and current whereas it is inversely dependent on the sample speed. Accordingly, the dose can be scaled by changing electron beam current when other parameters (*i.e.* voltage, air gap, emitter, ambient gas) remain constant.

Establishing Application Efficiency

At any fixed sample speed and beam current, the absorbed dose D at the target surface is measured using radiachromic films. A detailed discussion of dosimeter use and measurement techniques can be found in the AEB application note: *Dosimetry for Low Voltage Electron Beams for AEB Customers*[1]. The dosimeter film should be placed on the sample location at the point where the minimum dose requirement must be met for the end user's application. When the film is exposed to the electron beam irradiation, the radiation induces a chemical reaction that causes a color change, which can be measured by the change in optical density (ΔOD). The measured optical density and thickness of the film are used to calculate the absorbed dose using a calibrated conversion equation, traceable to a national standards laboratory.

Once D is measured for a known S and I, K can be determined by rearranging equation (1) as follows:

$$K = \frac{D * S}{I} \tag{2}$$

It is important to remember that K is constant at any given accelerated voltage, air gap, and ambient gas for a specific electron beam emitter. **It is essential to establish a new K when any process parameters are changed or a new emitter is installed.**

Once K is established and entered into the AEB controller system, the electron beam current is now automatically established. This allows the system to deliver a desired absorbed dose at any given speed for the fixed accelerated voltage, air gap, and ambient gas. As a result, dose measurement using radiachromic dosimeter film is not necessary for every process run. We recommend that dosimetry be performed as routine monitoring step at appropriate intervals for the end user's processes.

References

1 Application note: Metrology-LVDose-01, *Dosimetry for Low Voltage Electron Beams for AEB Customers*, Advanced Electron Beams, April 20, 2009