TECHNICAL MEMORANDUM

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REVISION HISTORY: Initial Release

LOW ENERGY ELECTRON BEAM (80 – 300 keV):

OPTIONS FOR TRACEABLE DOSIMETRY SYSTEM CALIBRATION

RELEASE DATE: *04/20/2011*

The process of calibrating dosimeters is actually called Dosimetry System Calibration because the process calibrates the system as a whole and not just the routine dosimeters that are only a part of the system. A Dosimetry System is defined in ASTM E2628 and is comprised of the dosimeters, measurement instrumentation and their associated reference standards, and procedures for the system's use (this would include the calibration curve fitting and the software or other method used to routinely estimate a dose value). Since each of the components of the system can affect the accuracy of the measurement, the system must be calibrated as a whole. If components of the measurement system are changed, the user must assess any impact on the system's measurements before implementation and determine any impacts on the system calibration.

A calibration that is suitable for the *conditions of use* (provides dose measurements for a specific radiation facility from a specific measurement system) must be demonstrated to be valid under those conditions of use, or even better, actually conducted under the conditions of use. It also must be traceable to national or international standards, meaning that an unbroken chain of comparisons is linking the national standard with the dose measurement at the facility. The dose values used in calibration must be traceable, and this can be obtained if the doses are certified by an accredited laboratory.

This paper outlines the two methods that can be used to execute a traceable calibration of a dosimetry system for low energy electron beam under conditions of use.

Prerequisites:
Before performing a traceable dosimetry system calibration using either of the methods described below:

1) IQ and OQ of the dosimetry system must be complete and, therefore, standard operating procedures for the use of the system for making dose measurements must be in place.
2) IQ of the radiation processing system must be complete.
3) The required dose range needed for the dosimetry system must be defined.

Method 1: In-Plant Calibration
Irradiation of dosimeters in the irradiation unit in which they will be routinely used alongside transfer standard dosimeters issued from and measured by an accredited laboratory.

It is currently only possible to perform this method by using alanine film reference-transfer dosimeters with dose expressed in terms of Dμ. This service is only offered by GEX through Risø High Dose Reference Laboratory in Denmark.

To execute the irradiations, the B3 dosimeters are arranged in a standardized orientation alongside the alanine films and irradiated to a series of doses that will define the final calibration curve and dose range. As an example, to calibrate from 10 to 50 kGy, the user will set beam parameters to target doses of 10, 20, 30, 40 and 50 kGy and irradiate a set of samples at each of these target doses. After irradiation, B3 films are handled according to standard procedures (heat-treated and measured by the user), and the alanine films are sent back to the laboratory where they will be measured. The laboratory issues a certificate for the dose measurements of the alanine dosimeters and the user can then complete a calibration curve using the resulting data.

This results in a dosimetry system calibration that is directly traceable to a national standard via an accredited laboratory and all data is derived under conditions of use, hence the title, in-plant calibration.

Method 2: 10 MeV Calibration with Verification In-Plant
Irradiation of B3 dosimeters in a high energy electron beam (10 MeV) alongside transfer standard dosimeters followed by an in-plant audit at a minimum of 3 dose levels (low, medium and high) using the same technique as method 1.

This method requires 2 stages of irradiation. The first is performed by an accredited laboratory and the user must send B3 samples to the lab for irradiation. After irradiation to the required dose levels, the lab returns the B3 dosimeters for measurement at the user's facility. The laboratory issues a certificate for the dose measured by the transfer dosimeters and the user can now complete a calibration curve using the resulting data.

Then the user must perform a verification audit of the calibration curve under the *conditions of use*, using method 1, at a minimum of 3 dose levels. The user must determine acceptance criteria for the verification audit, where the certified transfer dose is compared against the B3 dose estimated using the 10 MeV calibration curve that was derived at the start of the process.

Discussion:
Due to the added complexity of Method 2 and because both methods require in-plant irradiation of samples, GEX finds it is easier and more cost-effective to use Method 1 for the majority of users. Also, the use of Method 1 captures the majority of the components of uncertainty in the calibration exercise, which makes the estimation of overall uncertainty of dose measurement easier for the user.

Published Research:
Published research regarding the calibration of B3 film using low energy electron beam indicates that the response of B3 dosimeters irradiated at 100 keV is equivalent with the response at 10 MeV within the measurement uncertainties. This may cause some to believe that simply calibrating dosimeters using 10 MeV electrons and measurement of them on the user's dosimetry measurement equipment should constitute an accurate calibration for use on a low energy electron beam. However, if the conditions during the irradiations are not the same, and if account is not taken of limited penetration of the low energy beam, large errors can occur. Therefore, the published research only helps us to understand the response of the dosimeters in low energy electron beam irradiation, but can't be used as a rationale for not verifying the actual B3 dosimeter response under conditions of use. Doing so would constitute a break in the chain of traceability. For more information about the specific published research on the calibration of dosimeters in low energy electron beam and the Dμ concept, please contact GEX.

Caveat:
In order to execute in-plant irradiations, the electron beam parameter for beam current and the conveyor line speed must be adjustable to the extent that the user can irradiate dosimeters to the desired dose levels needed for the calibration. The user can perform initial testing simply using only B3 films to verify that he is able to accomplish this.

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