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NOTES ON THE CALIBRATION OF ROUTINE DOSIMETERS IN RADIATION PROCESSING

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Abstract
The essential prerequisite of radiation dosimetry is to provide quality assurance and documentation that the irradiation procedure has been carried out according to specifications requirement of the correct calibration of the chosen dosimetry system. In the Radiation Plant at the Vinča Institute, we compared two recommended protocols in calibration of dosimetry systems in radiation processing: (i) by using standardized routine dosimeters (ethanol-chlorobenzene ECB) from the reference laboratory and (ii) by in-plant calibration with the alanine transfer dosimeters. The analysis of results showed that our in-plant calibration is as good as when standardized dosimeters are used, thus validating our irradiation geometry in the irradiation process.

Introduction
Radiation processing in all areas requires proper use and selection of a dosimetric system for the measurement of the absorbed dose. Quality control is based on the validation of the calibration procedure and the assurance that the process was performed within prescribed dose limits. International guides for calibration of dosimeters recognize two possible procedures [1]: (i) Calibration of the routine dosimetry system can be carried out directly in a national or accredited standard laboratory by standardized irradiation of routine dosimeters. (ii) An alternative method requires routine dosimeters to be irradiated together with reference or transfer-standard dosimeters in the production irradiator (in-plant calibration). The first method is preferred by many, however one NPL report [2] recommends in the first place calibration by irradiation in the plant where the dosimeters are to be used, because this procedure accurately reflects conditions under which actual irradiation occurs. The present article evaluates both of the recommended methods and investigates their advantages and disadvantages in concrete irradiation conditions in gamma radiation processing at the Radiation Plant of the Vinča Institute using ethanol-chlorobenzene (ECB) dosimeters as routine dosimeters.

Experimental
The ECB dosimeters were prepared at the Vinča Institute in accordance with the procedures described in the corresponding standard [3] and placed in 2 ml glass pharmaceutical ampoules and flame-sealed. One batch (I) was sent for calibration to the Riso High Dose Reference Laboratory (HDRL). The second batch (II) was prepared to be used as routine dosimeters. The phantom with dosimeters consisted

of: (i) three ampoules with an ECB solution (batch II), (ii) two ECB ampoules from batch I, and (iii) an alanine dosimeter, supplied by HDRL, for in-plant calibration were placed in the central part of the box with the product for sterilization and irradiated in sterilization cycles between 5 – 35 kGy. The absorbed doses of the ECB dosimeters were measured by the oscillotitrator OK – 302/2, while the alanine dosimeters were sent to HDRL for dose determination.

Results and Discussion

The results of the calibration procedure of routine dosimeters are presented in Table 1 and in Fig. 1. The differences of absorbed doses measured by standard alanine and ECB dosimeters are within 1%, which is an excellent agreement between two methods. This is important since these two dosimeters have different geometry (thin alanine pellets vs. 'bulky' ECB ampoules) and the dose gradient within the calibration phantom can induce a difference in the dose delivered to these two dosimeters. The absorbed doses from Table 1 were used for construction of the calibration diagram for the new batch of ECB dosimeters (Fig.1).

Table 1. Absorbed dose as measured by standard alanine and ECB dosimeters.

Alanine dosimeters measured in HDRL	6.2 kGy	12.7 kGy	23.8 kGy	34.5 kGy
ECB dosimeters calibrated by HDRL	6.2 kGy	12.8 kGy	23.9 kGy	34.1 kGy

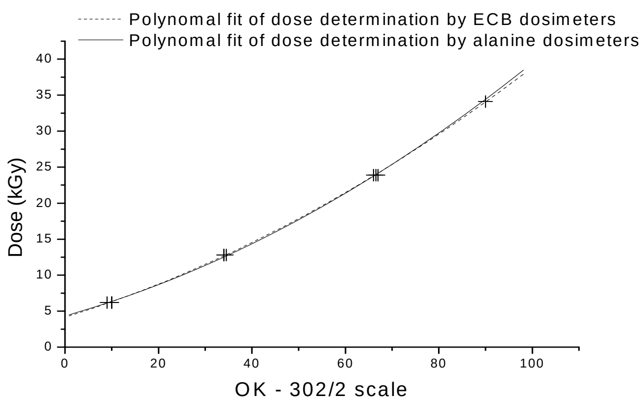

Fig.1. Calibration curves for the new batch of ECB dosimeters (routine dosimeters). The oscillotitrator readings are compared to doses measured by the two standard dosimeters. Curves represent the second order polynomal fit for doses between 5 – 35 kGy.

According to the international standards [2, 4] the test for the goodness of fit for the calibration curve is a residual difference between the measured and predicted values. The lower value for residual means a better fit. Figure 2 presents the residuals of calibration curves presented in Fig.1. As can be seen, residuals of these two calibrations are also very similar. The highest value for residuals is ±2% for doses below 10 kGy. Residual decreases when the absorbed dose increases, which is expected because the relative error is smaller when the measured value increases. This shows that our in-plant calibration using the alanine dosimeters appears to be as good as the one using the ECB standards.

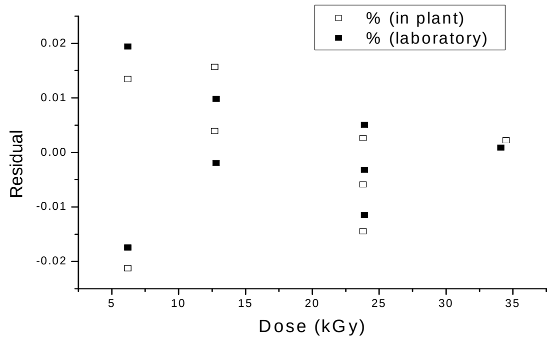

Fig.2. Residuals for curves presented in Fig. 1.

For in-plant calibration the critical point is irradiation geometry. An erroneous positioning of the irradiation phantom during irradiation can be the source of error in dose determination for calibration, so this position shall be validated. For that purpose one should calculate overall uncertainties according to [2, 4, 5]. The uncertainties of the nominal dose for dosimeters irradiated in HDRL are: ECB ampoules 3%; alanine 2.6%. In our conditions, the difference between the two dosimeters is less than 1% (Table 1). The effect of irradiation temperature on the reading of the dosimeter should be considered, since readings of alanine dosimeters are temperature sensitive, while ECB dosimeters are not. Knowing the temperature range during irradiation and according to the standard [6], the estimated uncertainty is 1.3%. Hence, the combined standard uncertainty is 3.1% for in-plant calibration using alanine dosimeters.

In conclusion, both irradiation procedures for dosimeter calibration have the same level of uncertainty; hence in-plant calibration is certainly the method of choice providing the careful placement of the irradiation phantom.

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