Estimation of Budget Uncertainty in a Personal Dosimetry Laboratory

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Abstract: - The purpose of a personal dosimetry laboratory is to accurately report the equivalent dose for occupational exposure workers and the degree to which the reported value is a good estimate of the true one. The uncertainty budget refers to a comprehensive analysis of the factors contributing to the overall uncertainty in determining the measurement.The purpose of this study is to estimate the budget uncertainty associated with six quantities that influence the overall uncertainty associated with the measurement. To precisely calculate the equivalent dose for occupational exposure workers using the whole bodydosimeters, we use the absolute standard uncertainties, which include the reader calibration factor (RCF), element correction coefficient (ECC), zero dose reading, non-linearity, radiation energy, and direction of radiation incidence, and measured value. The coverage factor, k = 2, estimates the overall measurement uncertainty at 22%. All the input quantities have a significant influence on the uncertainty of measurement, with the variation in response in different qualities and angles having the largest contribution, followed by the variation to response in different amounts of radiation (non-linearity). Less but not insignificant influence is exerted by the other input quantities.

Key-Words: - Equivalent dose, budgetuncertainty, reader calibration factor, element correction coefficient, zero dose reading, non-linearity, radiation energy and direction of radiation incidence, overall uncertainty.

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1 Introduction

Ionizing radiation exposure at work may result from the use of radioactive sources in various human endeavors. The worker's occupation is responsible for the occupational exposure, which they either receive or incur during their work. To control this exposure, individuals involved in such activities must assess the magnitude of their doses, [1]. The exposure to external radiation sources critically depends on the radiation type, energy, and conditions of the exposure. The International Safety Standards [2] and the Annals of the ICRP [3] establish the requirements for the protection of exposed workers from radiation sources. Operators should use operational quantities for personal dosimetry, according to specific rules and guidelines. These include the personal dose equivalent Hp(10) for strongly penetrating radiation, the dose equivalent to the eye lens Hp(3), and the dose equivalent to the skin Hp(0.07), [1]. Occupational exposure workers wear thermoluminescence dosimeters (TLDs), optically stimulated luminescence detectors (OSL), film badges, and electronic personal dosimeters (EPDs) to measure these operational quantities. To ensure satisfactory performance in individual monitoring of external exposure, calibrate the active or passive detectors and devices according to the operational quantities, [4]. Individual monitoring services should control exposure to workers by the regulatory body's defined dose limits for occupational workers and support the necessary measures to reduce the doses, [5]. Regulatory bodies base their decisions for occupationally exposed workers on the results of personal dosimeters compared to different dose limits. Reduced dose limits have increased the demands on individual monitoring in terms of accuracy, performance, and recording levels. We should always evaluate measured doses to confirm that the recorded dose accurately reflects the worker's received dose. Overexposure or underexposure to the received dose by workers due to inaccurate dose measurements can lead to health risks and unnecessary protective measures. It is crucial to provide accurate reports of the measured dose, including the extent to which the reported value is a reliable estimate of the true one. The improvement of a measurement quality is when it falls within a confidence interval, with a higher probability. Determining the uncertainty that yields the most accurate estimate of the quantity to be measured, even if it deviates from the instrument's given quantity, is a crucial process. Individual monitoring can enhance measurement results by utilizing information beyond the instrument's indication, [6]. The combined effects of two types of uncertainties, Type A and Type B, determine the overall uncertainty in a personal dosimetry laboratory. This study aims to estimate the budget uncertainty associated with six quantities that influence the overall measurement uncertainty. The absolute standard uncertainties stem from various factors, such as the Reader Calibration Factor (RCF), the Element Correction Coefficient (ECC), zero-dose reading, non-linearity, radiation energy, and direction of radiation incidence. Additionally, the measured value from the whole body dosimeter aids in determining the equivalent dose for occupational exposure workers more accurately. In this study, we don't consider the uncertainties that might arise from the users; we are going to estimate the uncertainties coming from the measurements. In the future, we will expand this study to encompass additional sources of uncertainty that impact the dose measurement, including fading factor, background, temperature, and environmental conditions. Additionally, we will explore the potential use of Monte Carlo simulations to evaluate the propagation of uncertainty in the measurement process.

2 Material and Method

2.1 Materials and Dosimetry Procedures

The estimation of occupational exposure of all workers who work with ionizing radiation in Albania is performed at the personal dosimetry laboratory, [7]. The personal dosimetry laboratory uses thermoluminescent dosimeter cards (TLD-100) containing lithium fluoride (LiF: Mg, Ti) detectors for whole-body dose measurements. In personal or environmental dosimetry, it is required for a TL dosimeter to have both tissue equivalency and high sensitivity. We chose the TLD-100 cards because of their near tissue equivalence, relatively low fading, adequate sensitivity for personnel dosimetry, and lack of light sensitivity, which facilitates easy handling. The laboratory provides personal dosimetry services on a bimonthly basis to occupationally exposed workers. Workers wear the TLD cards on their chests during their work shifts.The Secondary Standards Dosimetry Laboratory (SSDL) annually calibrates the HARSHAW 4500 Reader using a Cesium-137 (Cs-137) radiation source with a reference dose, and every three years, it calibrates the dosimeters (TLD cards) using a Sr-90 irradiator check source with a reference dose, [8], [9], [10]. Each TLD card undergoes a dose evaluation process that involves measurement with a Harshaw 4500 Reader, followed by correction using the reader calibration factor (RCF), element correction coefficient (ECC), and zero dose reading ($D_{av,0}$). For each batch of TLD cards, perform zero dose readings (intrinsic background) of the detector at least twice after the first reading. Next, we calculate an average zero dose and subtract this value from the measurement dose reading.

The determination of dose for whole-body dosimeters is determined using the formula (1):

$$Hp(10)_i = \frac{(D_i - D_{av.0})}{RCF} ECC_{ij} \quad (1)$$

where, $Hp(10)_i$ is the personal equivalent dose for strongly penetrating radiation with a depth of 10 mm,D_i isthe measured value of the detector i in nC given by the reader, $D_{av,0}$ is the average zero dose reading in nC, ECC_{ij} is the individual relative sensitivity of detector ion card j (Element Correction Coefficient) dimensionless, and RCF is the reader calibration factor in nC/μSv.

2.2 Estimation of Uncertainties

The measurement serves the purpose of providing information about the quantity of interest. The accuracy and precision of a measurement are dependent on various factors, including the measuring system, the measurement procedure, the operator's skill, the environmental conditions, and the lack of errors. The inaccuracy of a measurement result is referred to as uncertainty. Estimating the measurement's uncertainty is necessary to accurately determine the equivalent dose for occupational exposure workers using the whole-body dosimeter. We use the GUM (Guide to the Expression of Uncertainty in Measurement) framework to estimate the contribution of various factors to the overall uncertainty associated with the measured dose. These influences on quantities are not directly measured, but they still have an impact on the dosimeter's reading or the quantity being measured. The GUM necessitates the definition of a mathematical model that links the output quantity (measured dose) to input quantities (influential parameters), including the measured value, RCF, ECC, and zero dose reading. This model also incorporates a correction factor for radiation energy and the direction of radiation incidence, and a linearity correction factor, [6], [11], [12]. We calculate the individual contributions to the overall uncertainty of the measured dose and then determine the absolute standard uncertainty for each input quantity. Using the model function, the dose in μSv is determined as follows:

$$M_{corr.} = \frac{(D_{dose} - D_{av.\,zero})}{N_{RCF}} \times k_{lin.} \times k_{E,\alpha} \times k_{ECC} \qquad (2)$$

where, D_{dose} is the indication of the dosimeter in nC, $D_{av.\,zero}$ is the deviation due to zero indication of the dosimeter in nC, N_{RCF} is the reader calibration factor (nC/μSv), the correction factor for radiation energy and direction of radiation incidence is $k_{E,\alpha}$, the correction factor for linearity is k_{lin}, and the correction factor for the element correction coefficient is k_{ECC}.

2.2.1 Reader Calibration Factor Uncertainty Estimation

The Secondary Standards Dosimetry Laboratory (SSDL) determines the reader calibration factor (RCF) for the Harshaw 4500 Reader. We find the reader's calibration factor once a year, [8], [9], [10]. In our case, we irradiated in the SSDL place, 5 TLDs, to determine the calibration factor. We used a Cs-137 radiation source with an incident angle of 0°, to achieve a reference dose of 5 mSv, while maintaining a distance of 2 m from the source. We measured the dosimeters in a Harshaw 4500 Reader 24 hours after their radiation in the SSDL.

Formula (3) determines the calibration factor for dose evaluation in formula (1).

$$RCF = \frac{Hp(10)_{av.}}{D_{ref.} * 1000}\left(nC/_{\mu Sv}\right) \qquad (3)$$

where, $D_{ref.}$ is the reference dose in mSv given by SSDL using the ^{137}Cs source, $Hp(10)_{av.}$ is the average dose measured for our cards in nC after irradiation in the SSDL.
The formula (4) calculatesthe personal equivalent dose for each dosimeter $Hp(10)_i$:

$$Hp(10)_i = (D_i - D_{av.0})xECC_{ij} \qquad (4)$$

$$RCF = \frac{(D_i - D_{av.0})}{D_{ref.} * 1000}xECC_{ij} \quad \left(\frac{nC}{\mu Sv}\right)$$

where D_i is the dose measured for each dosimeter in nC, $D_{av.0}$ is the average zero dose reading in nC, and ECC_{ij} is the element correction coefficient of detector i for each dosimeter j.

The formulas (3) and (4) associate the absolute standard uncertainty for u_{sRCFi} with the given parameters, which we can determine using the absolute value of the partial derivative of the functions for the specific input quantity and the standard uncertainties of the input quantities. Therefore, the geometrical sum of all contributing factors determines the absolute standard uncertainty for u_{sRCFi} is calculated using formula (5):

$$u_{s_{RCFi}} = \frac{D_i - D_{av.0}}{D_{ref.}}xECC_{ij}\sqrt{\frac{(u_{s_{Di}})^2}{(D_i - D_{av.0})^2} + \frac{(u_{s_{Dav.0}})^2}{(D_i - D_{av.0})^2} + \frac{(u_{s_{Dref.}})^2}{(D_{ref.})^2} + \frac{(u_{s_{ECCij}})^2}{(ECC_{ij})^2}} = 0.001\frac{nC}{\mu Sv} \qquad (5)$$

The absolute standard uncertainty for the reader calibration factor after computing the values of all factors in the given formula (5) is found to be:

$$u_{s_{RCFi}} = 0.001\frac{nC}{\mu Sv}.$$

2.2.2 Estimating Uncertainty for ECC

Correction factors are used to normalize the sensitivity of an individual dosimeter elementto the mean sensitivity of a reference population (calibration set) exposed to the same source, [12]. The estimation of the ECC is as follows:

$$ECC_{ij} = \frac{QxRCF_i}{Q_{ij}} \qquad (6)$$

where, ECC_{ij} is the element correction coefficient for detector i on card j dimensionless, RCF_i is the reader calibration factor for i^{th} photomultiplier tube in, Q_{ij} is the reported charge from detector i on card j in nC, and Q is the ^{90}Sr exposure value in μSv [9], [10], [13].

We irradiated 61TLD cards using the Sr-90 check source in place, and measured the results in the Harshaw 4500 Reader 24 hours after the irradiation; the mean value and the standard deviation are represented by $ECC_{av.}$=1.047, s_{ECC}=0.09713, respectively. If we assume the data distribution as a normal distribution, the absolute standard uncertainty of the ECC is:

$$u_{s_{ECC}} = \frac{s_{ECC}}{3} = 0.032 \quad (7)$$

2.2.3 Estimating Uncertainty for Zero Dose Reading

To correct the additive doses arising from other sources than irradiation processes, it is important to determine thezero dose reading of the thermoluminescence dosimeters parameter. This zero dose compromises the readout system background plus the intrinsic background of the detectors. The IAEA Safety Standard, [12], [14] specifies that we can determine the intrinsic backgrounds of detectors individually or in batches. We measure the dosimeters at least twice after the first reading to determine the zero-dose reading for a batch of dosimeters, which represents the intrinsic background of the detector. Next, we calculate the average zero dose and subtract this value from the Harshaw reader's measurement dose reading. Repeated readout cycles are necessary to reduce the residual signal after a high beta/gamma exposure on a dosimeter; otherwise, the high residual TL from the previous high exposure will overestimate the exposure. In our case, we have used a batch of 19 TLD cards. The data distribution of the zero dose measurements fits a normal distribution with a confidence interval of 95%; (Figure 1).

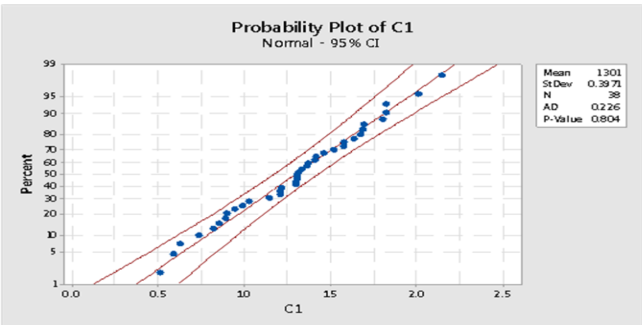

Fig. 1: The probability plot of data distribution for the zero dose reading values (using Minitab 18 statistics package), [15]

The mean value of the zero doses and the standard deviation are $D_{av.zero}$=1.301nC and $s_{Dav.zero}$=0.397, respectively, and the absolute standard uncertainty of zero dose reading is:

$$u_{s_{D_{av.\,zero}}} = \frac{s_{D_{av.\,zero}}}{3} = 0.132 \text{ nC} \quad (8)$$

2.2.4 Estimating Uncertainty for Non-Linearity

The correction for non-linearity is the $k_{lin.}$ quotient is given as a ratio of the TL response R_n under conditions where only the equivalent dose value varies and the reference response R_0. The $k_{lin.}$ is equal to unity for a linear dosimetry system [16].

$$k_{lin} = \frac{R_n}{R_0} \quad (9)$$

To find the linearity correction factor, we irradiated 12 TLDs with Cs-137 and Co-60 sources in the SSDL in the Dosimetry Department of the Greek Atomic Energy Commission. The doses were different from the reference doses. Table 1 (Appendix) displays the radiation quality data, reference values reported by the irradiating laboratory, values reported by the Harshaw 4500 Reader, and the linearity response or correction factor.

We estimate the uncertainty of the correction factor for linearity, assuming that the best estimation is the average value $k_{lin.}$=0.758 of the reported mean values, and the standard deviation is $s_{klin.}$=0.0674. The highest relative deviation from the best estimation 1 is 33% (Table 1, Appendix). We assume the distribution is rectangular and find the uncertainty using the formula below:

$$u_{s_{k_{lin.}}} = \frac{s_{k_{lin.}}}{\sqrt{3}} = 0.039 \quad (10)$$

2.2.5 Estimating Uncertainty for Radiation Energy and Direction of Radiation Incidence

For determination of the relative response due to mean photon radiation energy and angle of incidence, we have used the following radiation qualities specified in the ISO 4037 series: such as N-60, N-150, S-Cs (^{137}Cs), S-Co (^{60}Co), [17], [18]. The Dosimetry Department of the Greek Atomic Energy Commission performed irradiations for energies and angles of incidence of 0° and 60°, and only for two radiation qualities, N-60 and N-150, at a given dose at the SSDL. We have irradiated 4

TLDs, and for each energy and angle we used two TLD cards (Table 2, Appendix).

We found the mean value to be $k_{E,\alpha}$=1.128, and the standard deviation $sk_{E,\alpha}$=0.127. If we want to find the absolute standard uncertainty of the correction factor for radiation energy and direction of radiation incidence, we assumed the distribution to be rectangular and used the following formula to find the uncertainty:

$$u_{s_{E,\alpha}} = \frac{s_{E,\alpha}}{\sqrt{3}} = 0.073 \qquad (11)$$

2.2.6 Estimating the Measured Value's Uncertainty

The dosimeter will give the gross dose after subtraction of the zero doses (blank indication) and after the application of correction and calibration factors, which is also known as the measured value. The gross dose in general will include a contribution from natural background radiation in addition to any dose from the worker's occupational exposure, [14]. To determine the absolute standard uncertainty of the measured dose, we irradiated 6 TLDs with 2 mSv in ^{137}Cs-137 source at 0° angle at SSDL in place and measured in a Harshaw 4500 Reader, which gives the dose measured in nC. We found the mean value of the measured dose to be D_{dose}=56.611nC, and the standard deviation s_{Ddose}=3.647nC. If we assume the data distribution to be normal, the uncertainty of the measured dose is:

$$u_{s_{D_{dose}}} = \frac{s_{D_{dose}}}{3} = 1.216\,nC \qquad (12)$$

3 Sensitivity Coefficient Estimation

The standard uncertainty $u(\hat{m})$ of the output quantity $\hat{m}$ depends on the absolute standard uncertainty of the input quantities. In our case, the output quantity $(\hat{m})$ depends on the absolute standard uncertainties of the given input parameters at the formula (2), $u_D(\hat{m})$, $u_{Dav.zero}(\hat{m})$, $u_{RCF}(\hat{m})$, $u_{ECC}(\hat{m})$, $u_{kE,\alpha}(\hat{m})$, $u_{klin.}(\hat{m})$. The sensitivity coefficients provide a measure of how sensitive the measurand is to a change in given input quantities. Mathematically, the sensitivity coefficient is the change of the output quantitydue to a change of an input quantity, for example, if Δm is the change of the output quantity due to the change of the input quantity Δx, the sensitivity coefficient is given as $\frac{\Delta m}{\Delta x}$ [6]. Using the partial derivative [19], [20] for the model function of the measurements for the particular input quantities in the formula (13) we'll take the sensitivity coefficient using the partial derivative, respectively:

$$M_{corr.} = \frac{(D_{dose} - D_{av.\,zero})}{N_{RCF}} \times k_{lin.} \times k_{E,\alpha} \times k_{ECC} \qquad (13)$$

$$c_{D_{dose}} = \frac{\partial M}{\partial D_{dose}} = \frac{1}{N_{RCF}} \times k_{lin.} \times k_{E,\alpha} \times k_{ECC}$$

$$c_{D_{av.zero}} = \frac{\partial M}{\partial D_{av.zero}} = -\frac{1}{N_{RCF}} \times k_{lin.} \times k_{E,\alpha} \times k_{ECC}$$

$$c_{N_{RCF}} = \frac{\partial M}{\partial N_{RCF}} = -\frac{(D_{dose} - D_{av.zero})}{{N_{RCF}}^2} \times k_{lin.} \times k_{E,\alpha} \times k_{ECC}$$

$$c_{k_{ECC}} = \frac{\partial M}{\partial k_{ECC}} = \frac{(D_{dose} - D_{av.zero})}{N_{RCF}} \times k_{lin.} \times k_{E,\alpha} = \frac{(56.611 - 1.301)}{0.0208} \text{ x } 0.758 \text{ x } 1.128 = 2273.62\ \mu Sv$$

$$c_{k_{lin.}} = \frac{\partial M}{\partial k_{lin.}} = \frac{(D_{dose} - D_{av.zero})}{N_{RCF}} \times k_{E,\alpha} \times k_{ECC}$$

$$c_{k_{E,\alpha}} = \frac{\partial M}{\partial k_{E,\alpha}} = \frac{(D_{dose} - D_{av.zero})}{N_{RCF}} \times k_{lin.} \times k_{ECC}$$

The contributions of the standard uncertainties of the input quantities to the standard uncertainty associated with the output quantity are given below and according to GUM they are positive so the absolute values of sensitivity coefficient and absolute standard uncertainty are used:

$$u_{D_{dose}} = \left| c_{D_{dose}} \times u_{s_{D_{dose}}} \right|$$

$$u_{D_{av.zero}} = \left| c_{D_{av.zero}} \times u_{s_{D_{av.zero}}} \right|$$

$$u_{N_{RCF}} = \left| c_{N_{RCF}} \times u_{s_{N_{RCF}}} \right|$$

$$u_{k_{ECC}} = \left| c_{k_{ECC}} \times u_{s_{k_{ECC}}} \right|$$

$$u_{k_{lin.}} = \left| c_{k_{lin.}} \times u_{s_{k_{lin.}}} \right|$$

$$u_{k_{E,\alpha}} = \left| c_{k_{E,\alpha}} \times u_{s_{k_{E,\alpha}}} \right|$$

The overall uncertainty $u(\hat{m})$ associated with the output quantity $\hat{m}$ is given by the geometrical sum of all these contributions, formula 14:

$$u(M_{corr.}) = \sqrt{{u_{D_{dose}}}^2 + {u_{D_{av.zero}}}^2 + {u_{N_{RCF}}}^2 + {u_{k_{ECC}}}^2 + {u_{k_{lin.}}}^2 + {u_{k_{E,\alpha}}}^2} \quad (14)$$

The expanded measurement uncertainty is obtained by multiplying the standard measurement uncertainty by a coverage factor, k that gives a higher probability that the correct value lies within the range of the stated uncertainty.

$$U = k \times u(M_{corr.}) \quad (15)$$

To find what level of certainty a particular output quantity M has when its mean is determined as $M_{corr.}$, we use the equation (16), [19], [21]:

$$M = M_{corr.} \pm U \quad (16)$$

The value of the output quantity, with the coverage factor k = 2, normally lies, with a probability of approximately 95%, within the attributed coverage interval, [22], [23]. For a measurement in a single field component with a quantity value equal to or greater than 1 mSv (annual limit dose for members of the public), the combined standard uncertainty should be less than 30% for photon/electron workplace fields. The expanded uncertainty (coverage factor of 2) given by the ICRP of 40% is close to the 95% confidence interval of 0.67 to 1.5 (factor 1.5) given by the ICRP, [24].

4 Discussion of the Results

The complete uncertainty analysis for measurement, [21], [25], also referred to as the measurement's uncertainty budget, encompasses all sources of uncertainty, including standard uncertainties u_s, uncertainty contributions $u(M_{corr.})$,and expanded uncertainty U with the coverage factor k=1, for all six input quantities, as presented in Table 3 (Appendix).

The RCF gives an estimate of 0.001nC/μSv, the element correction coefficient gives 0.032, the zero dose reading gives 0.132nC, the non-linearity gives 0.039, the radiation energy and direction of radiation incidence gives 0.073, and the measured value gives 1.216 nC.

Table 3's (Appendix) results indicate that the expanded uncertainty for the output quantity, based on the coverage factor k = 2, is approximately 22%, considering the uncertainties of the six input quantities that impact our measurement, [25].

The coverage interval of the output quantity M, estimated using formula 16, lies with a probability of 95% within the coverage interval.

The input quantities with the largest contribution to the overall uncertainty are the influence of different irradiation qualities and angles, and the variation in response to different amounts of radiation (non-linearity). The other input quantities have less but non-negligible influence.

In the future, we will expand this study to encompass additional sources of uncertainty that impact the dose measurement, such as the fading factor, background, temperature, and environmental conditions, and explore the potential of Monte Carlo simulations to evaluate the propagation of uncertainty in the measurement process.

5 Conclusion

The definition of the measurement model and the identification and calculation of the input quantities that have a significant influence on the uncertainty of measurement (UoM) are the key elements forbudget uncertainty estimation.

The contribution of six different quantities to the uncertainty of measurement has been calculated.

The estimation of the absolute standard uncertainty comes from the RCF at 0.001nC/Sv, the element correction coefficient at 0.032, the zero dose reading at 0.132nC, the non-linearity at 0.039, the radiation energy and direction of radiation incidence at 0.073, and the measured value at 1.216nC.

The calculation shows that all the input quantities have a significant influence on the UoM, with the variation in response in different qualities and angles having the largest contribution and the variation in response in different amounts of radiation (non-linearity).

The coverage factor k = 2 estimates the expanded uncertainty U to be 22%, which is a realistic value for a personal dosimetry laboratory.

The available information constrains the number of selected input quantities, but future work may allow for their expansion.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work the authors used Grammarly and Quillbot for language editing. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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APPENDIX

Table 1. Non-linearity test

Rad. Quality	SSDL$_{Ref.}$ value, $H_p(10)$ mSv	Reported values, $H_p(10)$ mSv	k_{lin}, (rep./true)	Best estimation	Abs(k_{lin}-1)
S-Cs-S/0°	0.9	0.60	0.67	1	0.33
S-Cs-L/0°	4.8	3.73	0.78	1	0.22
S-Co-L/0°	4.8	3.71	0.77	1	0.23
S-Co-M/0°	48	40.76	0.85	1	0.15
S-Co-H/0°	350	254.02	0.73	1	0.27

Table 2. Response to different radiation qualities and angles

Rad. Quality	$D_{ref.}H_p(10)$ mSV	$D_{rep.}H_p(10)$ mSv	Response R (Repo./Ref.)
N-60/0°	1.51	1.97	1.30
		1.55	1.03
N-150/60°	1.51	1.58	1.05
		1.70	1.13

Table 3. Uncertainty Analysis

Quantity	Best estimate		Absolute St. uncertainty u_s		Sensitivity Coeff. c_s		Uncertainty contribut., u($M_{corr.}$)	
D_{dose}	56.611	nC	1.216	nC	43.04	µSv/nC	52.34	µSv
$D_{av\text{-}zero}$	1.301	nC	0.132	nC	43.04	µSv/nC	5.68	µSv
RCF	0.0208	nC/µSv	0.001	nC/µSv	114395.63	µSv^2/nC	114.39	µSv
K_{ecc}	1.047		0.032		2273.62	µSv	72.76	µSv
k_{lin}	0.758		0.039		3140.48	µSv	122.48	µSv
$k_{E,\alpha}$	1.128		0.073		2110.36	µSv	154.06	µSv
M_{corr}	2170.04	µSv						
M_{corr}	2.170	mSv			Expanded Uncertainty, 11%	k=1,	0.240	mSv

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

I, Berdufi have made all the measurements using the Harshaw 4500Reader. I. Berdufi and F. Cfarku have written the main manuscript text. I. Berdufi and E. Musta have made the calculations and entered the formulas. I. Berdufi and D. Mitrushi have prepared figures and tables. All authors reviewed the manuscript and discussed the results and conclusions.

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Conflict of Interest

The authors have no conflicts of interest to declare.