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Interlaboratory comparison exercise using OSL personal dosimeters between the LMRI-DEN/UFPE, Brazil, and LCD/LAF-RAM, Nicaragua.

Somarriba[a] F.I., Khoury [b] H.J., De Barros [b] V.S., Roas[a] N.A.,
Meza [a], J.J and Dominguez [a], R.A

[a] *Laboratorio de Física de Radiaciones y Metrología/ Universidad Nacional Autónoma de Nicaragua, Rotonda Universitaria Rigoberto López Pérez 150 Metros al Este, Managua,663, Managua, Nicaragua.* fsomarri@yahoo.com

[b] *Departamento de Energía Nuclear, Universidade Federal de Pernambuco, 50740-540 Recife, PE, Brazil*

ABSTRACT

The aim of this paper is to present the results obtained in the intercomparison exercise organized by the Ionizing Radiation Metrology Laboratory at the Federal University of Pernambuco (LMRI-DEN/UFPE) and the Radiation Physics and Metrology Laboratory (LAF-RAM) of the National Autonomous University of Nicaragua, Managua (UNAN-Managua). The comparison aimed to assess the technical capabilities of the Dosimetry Calibration Laboratory (LCD) belonging to LAF-RAM for the irradiation of personal dosimeters in terms of Hp(d) magnitudes with a ^{137}Cs radiation beam. The BeO OSL dosimeters were shipped by LMRI-DEN/UFPE to LAF-RAM for irradiation in March 2020. The evaluation of the Z-Score value obtained in the intercomparison was satisfactory for all irradiations of the dosimeters in the Hp (d) magnitude.

Keywords: **intercomparison, OSL personal dosimeter, calibration.**

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1. INTRODUCTION

Interlaboratory comparison exercise is a method generally used to verify laboratory performance. It is an important test of meeting the requirements of ISO/IEC 17025 in the area of quality assurance of laboratory results. The laboratory can use this comparison exercise to verify the accuracy and reliability of its results, offering additional confidence to the customers. The International Organization for Standardization has established interlaboratory exercises as a requirement for the accreditation of laboratories that perform proficiency tests including dosimetric calibrations.

ISO/IEC 17025 set up general requirements for the competence of testing and calibration laboratories including participation in interlaboratory comparisons other than proficiency testing [1]. Consequently, collaboration was requested to the Laboratory at the Federal University of Pernambuco (LMRI-DEN / UFPE) to carry out an intercomparison exercise. The LMRI-DEN/UFPE accepted to participate and prepare a protocol to carry out the intercomparison with the Radiation Physics and Metrology Laboratory (LCD-LAF-RAM) of the National Autonomous University of Nicaragua, Managua (UNAN-Managua and to provide the reference value for this comparison. LMRI-DEN/UFPE has accreditation with ISO/IEC 17025:2017. The traceability of the calibration quantity of this laboratory is established in the use of a Secondary Standard Dosimeter, Ionization Chamber model TW32002, series 550 from PTW Freiburg, and a PTW Freiburg electrometer model UNIDOS E, series T10009-90284, calibrated on the LNMRI-IRD/CNEN. Calibration certificate no. LNMRI 1375/2018

Established in 2013, the LCD-LAF-RAM is the only service provider at the national level in Nicaragua that performs calibrations of area monitors and surface contamination meters and irradiations of personal and environmental dosimeters. The LCD is recognized and authorized by the regulatory authority of Nicaragua, the National Atomic Energy Commission (CONEA), to provide the services. The traceability of the calibration is established through the International Atomic Energy Agency (IAEA) Dosimetry Laboratory in Seibersdorf, Vienna. The LCD Secondary Standard Dosimeter system used to the calibration quantity, Ionization Chamber model TW32002, series number 585 from PTW Freiburg, and PTW Freiburg electrometer model UNIDOS Webline

T10022, series 554, were calibrated in April 2018 at the IAEA. Calibration certificate no. NIC/2018/1.

This paper presents the outcome of the intercomparison exercises between LMRI and LCD for the irradiation of personal dosimeters, using a source of ^{137}Cs. The results of this intercomparison were analyzed according to the ISO Standard 17043:2010[3], through the common En value

2. MATERIALS AND METHODS

2.1. Technical protocol for irradiation

The transfer instrument for the Hp (10) determination was a personal Optically Stimulated Dosimeter, manufactured by Dosimetrics GmbH, in plastic encapsulation, as worn by users. This dosimeter uses one beryllium oxide chip as the detector element for Hp(10) and one for Hp(0.07). The Hp(10) detector is covered with a filter made of Teflon and the Hp(0.07) detector is covered by a thin plastic layer. The filter of the Hp(10) element is made of 2.4 mm Teflon and the Hp(0.07) element is covered by 0.5 mm thick plastic window. For the calibration, were used the following phantoms:

• ISO water slab phantom of 30cm x 30cm x 15cm, for the whole body dosimeters;

• ISO rod phantom, for ring dosimeters;

• For eye lens dosimeters, a cylinder phantom ∅20 cm x 20cm PMMA (designed to simulate the human head for eye dosimetry calibration and testing);

Irradiations were restricted to the ^{137}Cs-photon radiation and will be carried out in the participating facility in terms of Hp(10), Hp(3) and Hp(0.07). Afterwards, irradiation of personal dosimeters was performed with a gamma beam irradiator (Hopewell Design, Inc) using a ^{137}Cs gamma ray source with 0.84 TBq (22.6 Ci). The gamma ray irradiator was calibrated in air kerma using a traceable standard ionization chamber.

The dosimeters were irradiated at doses of 2 mSv and 4 mSv, using the procedures of the LCD/LAF-RAM, on the surface of the ICRU slab phantom to represent the human torso, at 0° angle incidence and 2,5m from the source. The conversion coefficients adopted were under ISO Standard

4037-3:2019[2], while, for the quantity Hp(0.07) and Hp(3) irradiations were performed on a rod phantom and cylinder phantom, as shown in Fig 1. The reference point is the geometric center, corresponding to the position of the crystal.

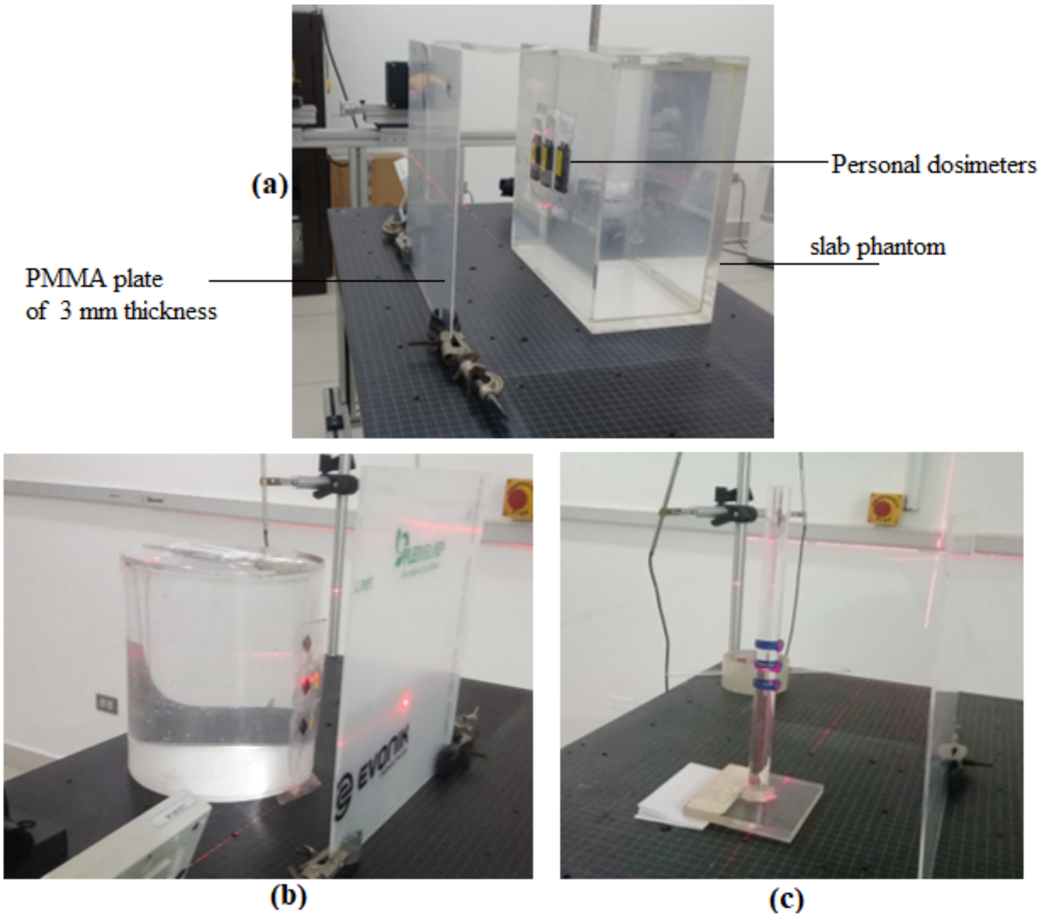

Figure 1: *Arrangement for the calibration of personal dosimeters in terms of (a)Hp(10), (b) Hp(3) and (c) Hp(0.07).*

After irradiation, dosimeters were returned to the reference laboratory LMRI-DEN / UFPE. The dosimeters were read as they were received by the coordinating laboratory, using their calibrated BeOSL Reader. The average response of the four unirradiated dosimeters (BG) was subtracted from the response of irradiated dosimeter to obtain the net value. The average of the 3 net values of irradiated dosimeters was then calculated

3. RESULTS AND DISCUSSION

The performance evaluation of the participating laboratory was conducted according to the ISO Standard 17043:2010[3], through the common E_n value determined according to equation 1.

$$E_n = \frac{(x-X)}{\sqrt{U_{lab}^2 + U_{ref}^2}} \tag{1}$$

Where:

x: is the participant's result

X: is the assigned value of the reference laboratory

U_{lab}: is the expanded uncertainty of a participant's result

U_{ref}: is the assigned value for the expanded uncertainty of the reference laboratory.

The acceptance criteria for the evaluation of E_n is established by the ISO Standard 17043:2010 as:

$|E_n| \leq 1.0$ Satisfactory.

$|E_n| > 1.0$ Unsatisfactory.

The calculation of the uncertainty Budget of the personal dose equivalent Hp(d) was obtained by applying ISO GUM JCGM 100: 2008[4], where the contributions of the beam calibration uncertainties and the type B uncertainties were established following recommended values from ISO 4037-3 (2019) [2].

Table 1 shows the results provided by the reference laboratory received in April 2020 and the measurement uncertainties of the participating laboratory. The uncertainties were reported as the relative expanded uncertainty at a confidence level of 95% (k = 2.00).

The results for En, obtained for the three magnitudes Hp (0.07), Hp (3), and Hp (10) were less than 1.0, indicating that the irradiation procedures performed from LCD/LAF-RAM are adequate and satisfy the requirements established from ISO Standard 17043:2010. Furthermore, the repeatability of the response of the BeOSL dosimeters is very good and with low fading.

Table 1: Results obtained and calculation of the E_n

Hp(d) Magnitudes	Nominal Value (mSv) + U (%)	Net average dose Measured (mSv) ± U (%)	$\|E_n\|$
Hp (10)	2.0 ± 4.1	2.0 ±10	0.02
	4.0 ± 4.1	4.2 ±10	0.47
Hp (0.07)	2.0 ± 4.1	2.2 ± 10	0.89
	4.0 ± 4.1	4.2 ± 10	0.55
Hp (3)	2.0 ± 4.1	2.0 ± 10	0.06
	4.0 ± 4.1	4.1 ± 10	0.17

4. CONCLUSIONS

This comparison exercise has shown that the irradiation procedures performed from LCD/LAF-RAM are adequate and satisfy the requirements of the ISO Standard 17043:2010 standard. The result gives a confidence to customers of the LCD/LAF-RAM on the high level of traceability and quality of the procedures adopted for the irradiation services offered.

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