New Quantities (Hp e H*) in Neutron Monitor Calibration

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ABSTRACT

Area or personal neutron monitors calibration in new quantities: Ambient dose equivalent (H*(10)) and Personal dose equivalent (Hp(10)), implicate in some alterations in calibration procedure applied in IRD/LNMRI/LN – Laboratório de Nêutrons, which were written for the quantity MAximum Dose Equivalent (MADE). The main alteration for the personal monitors is conversion coefficient variation in relation to the incidence angle of the neutron beam for a known energy. For the area monitors the conversion coefficients show variation in relation to the neutron incident energy. In face of this reality, it is necessary to make use of computational programs and electronic interfaces for adjust the answer of these instruments, implicating in a growing of necessary investments to make one calibration.

INTRODUCTION

The main responsibility of IRD/LNMRI/LN – Laboratório de Nêutrons is to maintain the ratreability of neutron measurements made in Brazil to the Brazilian Neutron Fluence Standard (AmBe neutron source – SN 3 066, 37GBq) and to the International Laboratories. Until 1999, all the calibrations of personal and area neutron monitors, made by IRD/LNMRI/LN were referenced to the quantity Maximum Dose Equivalent (MADE). This operational quantity is defined in a cylinder equivalent tissue with dimensions of 15cm diameter and 60cm height as described in ICRP 21.

Advent of new quantities bring the equipment makers to develop monitors which scales indicate results in personal dose equivalent , Hp(10) or ambient dose equivalent, H*(10). IRD/LNMRI/LN also began a process of studies to evaluate the impact of this change for the equipment's pre-existent and calibrated in MADE. The objective was to verify if would be possible to calibrate these "old" instruments in terms of the new quantities: Hp(10) or H*(10).

PERSONAL DOSE EQUIVALENT CALIBRATION, Hp(10)

The operational quantity personal dose equivalent, Hp(10), is the dose equivalent in soft tissue (ICRU 51) at 10mm depth below a specified point on the body.
The unit of the personal dose equivalent is J Kg^{-1} with the special name sievert (Sv).

In this manner, to make a neutron personal monitor calibration in terms of Hp(10) it is necessary to compute the dose equivalent at 10 mm deep in a phantom composed of ICRU tissue. Table 1 shows the conversion coefficients $hp\phi(10;E;\alpha)$ that convert neutron fluence (ϕ) to personal dose equivalent Hp(10) at 10 mm deep over the center of the face of a phantom simulator of 30cm x 30cm x 15cm with density of $1g.cm^{-3}$ for monoenergetic and parallel (expanded field) neutron beams, incident angles α.

Table 1: Conversion coefficients $h_{p\phi}$ (10;E,α) for α incidence angles.

Neutron Energy (keV)	$h_{p\phi}$ (10;E,α) in pSv.cm^2 for α incident angle of:					
	0º	15º	30º	45º	60º	75º
Thermal	11.4	10.6	9.11	6.61	4.04	1.73
2	8.72	8.22	7.27	5.43	3.46	1.67
24	20.2	19.9	17.2	13.6	7.85	2.38
144	134	131	121	102	69.9	22.9
250	215	214	201	173	125	47.0
565	355	349	347	313	245	115
1200	433	427	440	412	355	210
2500	437	434	454	441	410	294
2800	433	431	451	441	412	302
3200	429	427	447	439	412	309
5000	420	418	437	435	409	331
14800	561	563	581	572	576	517
19000	600	596	621	614	620	568

The necessity to utilize a phantom simulator for calibrating personal monitors of neutron, represents one significant change, mainly on the cases where these personal monitors do not utilize albedo´s principle (reflected radiation), for instance: pen dosimeters for neutrons. In MADE calibration condition, there is no necessity to utilize a phantom simulator but when an albedo´s personal monitors is calibrated it is utilized a phantom simulator to reflect the neutrons, in opposite way, he could not work correctly. Another important fact is that MADE does not presents any angular dependence with relation to the incident neutron beam. In this manner, for calibrating these albedo´s dosimeters in terms of Hp(10) is necessary to verify if they adequate themselves to variation that they show on their own response as a radiation incidence angle function, that why the new quantity presents this feature. In the case of neutron pen dosimeters, mainly those which detect thermal neutron, It is found two technical problems. The first one is the fact that a phantom simulator can not be attached to experimental arrangement utilized in order to calibrate. The second one is the fact that read values shown by the instrument´s scales can not be changed.

LN has verified, by means of results, that is possible to calibrate the albedo´s personal neutron monitor developed at IRD, in terms of personal dose equivalent making use of the new proposed conversion coefficients. Pen dosimeters keep on being calibrated in terms of MADE by IRD/LNMRI/LN due to technical problems (use of phantom simulator and scale indication as mentioned before).

AMBIENT DOSE EQUIVALENT CALIBRATION, H*(10)

The operational quantity ambient dose equivalent, H*(10), at a point in a radiation field, is the dose equivalent that would be produced by corresponding expanded and aligned field in the ICRU sphere at 10mm depth on the radius opposing the direction of the aligned field. The unity of the ambient dose equivalent is J Kg^{-1} with the special name sievert (Sv).

In relation to the area monitors calibration made for express the measurements result in terms of MADE, it is possible to make calibration of themselves in H*(10). The main change in this case for the reference fields was the fluence conversion coefficients to neutron equivalent dose. Table 2 shows the conversion coefficients h*ϕ(10;E) that convert neutron fluence (ϕ) to ambient dose equivalent H*(10) a 10 mm for monoenergetic and parallel neutron beam (expanded and aligned field).

Table 2: Conversion coefficients $h^{*}_{\phi}(10;E)$.

Neutron energy (keV)	$h^{*}_{\phi}(10;E)$ in pSv cm^2
Thermal	10.6
2	7.7
25	19.3
144	127
250	203
565	343
1200	425
2500	416
2800	413
3200	411
5000	405
14800	536
19000	584

To instruments indicate in terms of H*(10), it is necessary that manufacturers make one change over their scales. In general, when compared with the MADE indication that change will bring the instruments to present a greater value indication in terms H*(10). Simple Modification in the instruments scale does not presents big problems and can be done by manufacturer or its commercial representative.

In relation to neutron area monitors that already express their results in terms of ambient dose equivalent, there is no problem to calibrate them at IRD/LNMI/LN. For that, it is made use of the standard neutron field recommended by ISSO 8529 and the new conversion coefficients. IRD/LNMRI/LN has adopted the procedure to calibrate neutron area monitors in that quantity they were developed, that is, the new instruments are already been calibrated in terms of ambient dose equivalent. Nowadays, the calibration procedure used at our laboratory is not the problem for this to be make at IRD/LNMRI/LN, there is the necessity of the use of the new electronic interfaces that are of need to change some parameters of the neutron area monitors, in what they can indicate the nearest possible to the reference value of ambient dose equivalent. Each manufacturer has a different electronic interface for their instruments, IRD/LNMRI/LN needs to acquire each of them to calibrate the instruments, what implies in a glow of calibration cost for our laboratory, or pass this cost to the users that should acquire the electronic interface for their instruments.

CONCLUSION

Based on results obtained at IRD/LNMRI/LN – Laboratório de Nêutrons is adopting the following actions, with relation to the neutron monitors calibration in terms of the new quantities:

1 – For neutron personal monitors (Albedo type) that show good results in relation to their response indication in personal dose equivalent,Hp(10), will be calibrated in this quantity. The neutron pen dosimeters keep on being calibrated in terms of Maximum Dose Equivalent, MADE.
2 – The neutron area monitors whose scales express their results in terms of ambient dose equivalent, H*(10), will be calibrated in this quantity. IRD/LNMRI/LN might make the acquisition of the necessary electronic interfaces for calibrating these new instruments in terms of ambient dose equivalent.
3 – The old area monitors keep on being calibrated in terms of Maximum Dose Equivalent, MADE.

REFERENCE

ICRP 21 – ICRP Publication 21: Data for protection against ionizing radiation from external sources. ICRP. (1971).

ICRU 51 – ICRU Report 51: Quantities and units in radiation protection dosimetry. ICRU, Bethesda, MD. (1993).

ISO 8529 – ISO 8529: Neutron reference radiations for calibrating neutron-measuring devices. International Standard ISO (1989)