

DETERMINATION OF RADIATION DIRECTION IN ENVIRONMENTAL MONITORING

Vicente de Paulo de Campos, Eduardo S. Moura, Felícia. D. G. Rocha and
José Eduardo Manzoli

Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP

vpcampos@ipen.br; jmanzoli@ipen.br; edusantos_moura@ig.com.br; fgrocha@ipen.br

ABSTRACT

The assessment of environmental exposure has been performed in Brazil using the thermoluminescence technique at Thermoluminescence Dosimetry Laboratory (LDT), at Nuclear and Energetic Research Institute (IPEN/CNEN-SP). To carry out these measurements, several thermoluminescent dosimeters (TLD's) were used to measure the exposure. In this procedure, very few information of direction where the radiation came from is available. A vague supposition about the direction from where the radiation came from could be inferred only by evaluation of multiple dosimeters displaced at entire region of monitoring, but this demand to much effort or sometimes become impractical for certain situations. In this work, a single device is used to provide information about the direction from where the radiation came through. This device is called *directional dosimeter* (DD)[1]. Using more than one DD it is possible to reduce the uncertainty of the measurements and determine the radiation source position. The DD basically consists of a regular solid with high effective atomic number, where one TLD is positioned at each face. The DD allows evaluating the environmental exposure and the direction of the radiation by a simple vector sum. At each face of the DD, it is associated an orthogonal vector, and modulus of this vector represents the correspond exposure measured by the TLD. The direction of the radiation source is the sum of these faces vectors. The prototype used in this work was a lead cube with six TLDs of CaSO₄:Dy/Teflon. The TLDs have high sensibility and are already used in area, environmental and personal monitoring. The measurements had shown the correct environmental exposure and a good indication of the radiation direction.

1. INTRODUCTION

Thermoluminescence dosimeters (TLDs) are often utilized to perform environmental exposure measurements evaluations in Brazil and in others countries [2-4]. To carry out these measurements, several TLDs are used to measure the dose. In this procedure, very few information of the direction where the radiation came from is available. This information came only from the whole interpretation of the set of points measured. It is not unusual to be necessary at least 20 points, for a reasonable estimate of this direction.

This work evaluated the direction of the environmental radiation through a single directional dosimeter, DD [5,6]. This dosimeter indicates the exposure direction or the direction of major contribution for the environment exposure in the point of displacement. Two devices were placed in a site where radiation facilities do exist closely, like a ciclotron, a bunker of irradiation and small nuclear reactors. It is important to know the exposure and origin of the radiation in a certain point. This procedure helps the radioprotection staff for dose monitoring and security of the workers and better use in the construction of new facilities. In this work,

the DD is being used only to indicate the direction of the main radiation source that contributes to the environmental exposure.

2. METODOLOGY

2.1 Directional Dosimeter

The DD is a regular cube (4.5cm of side) made by lead, at each face it is placed a thermoluminescence dosimeter of $\text{CaSO}_4:\text{Dy}/\text{Teflon}$ [7] manufactured by IPEN-CNEN/SP, see Figure 1. The TLD (6.0mm in diameter and 0.8mm in length) showed high sensitivity and are used for environmental purposes, like area and individual ionizing radiation monitoring. Each face of the cube has one hole of 20.0mm diameter, where dosimeters were positioned. The holes have copper filters to minimize backscattering, following by a low density plastic to electronic equilibrium. This set was adopted and showed a good performance in low dose exposure area monitoring.

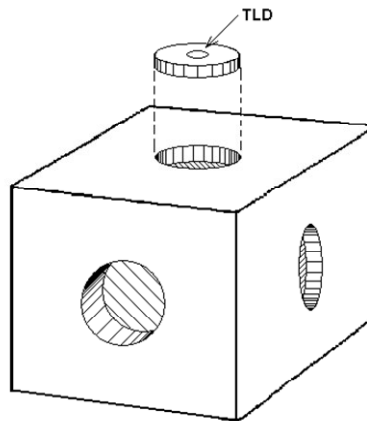


Figure 1: Sketch of the directional dosimeter, DD. One TLD is placed at each face of the cube. This cube has 4.5cm of side.

2.2 Experimental Procedure

DDs were positioned in a site where traditional environmental dosimetric measurements take place. For this work, two DDs were used. These dosimeters were designated by the letters **A** and **B**. These dosimeters were positioned in a monitoring area in the “head” of the two plastic rods of PVC with 1m height (Figure 2). The time interval required for the measurements was 90 days. This interval was chosen to give values far from the detection limit of environmental

exposure, because this region has a low background radiation. The $\text{CaSO}_4:\text{Dy}$ dosimeters were from a pre-select batch [8] and the temperature treatment was 300°C for 1 hour. The DDs were put into the support with a plastic cover to avoid weathering.

Figure 3 illustrates the positions of the dosimeters used in the region of measurements. The dosimeter faces were numbered like Figure 4, the face with number 4 is close to south direction. After 90 days, the dosimeters were evaluated in a TLD reader model Harshaw 5500.



Figure 2: Place for the environmental monitoring. Left: the PVC rods. Right: DD positioned inside the rod.

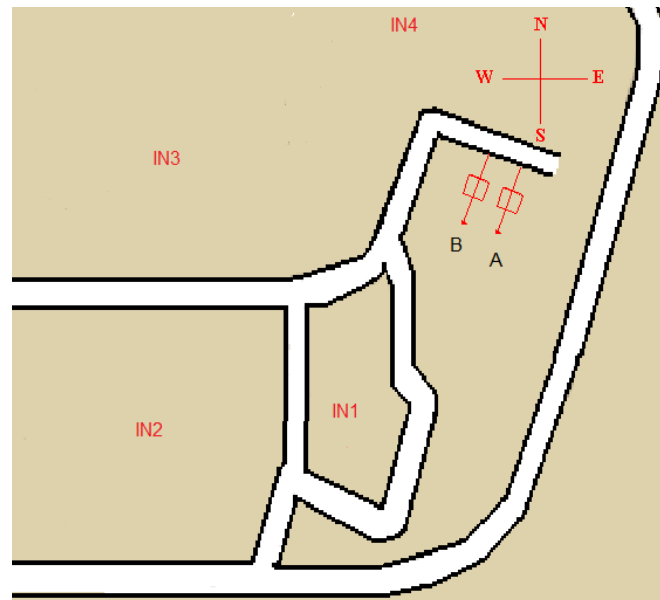


Figure 3: Map representation of DDs A and B positions and the four radioactive or nuclear facilities (IN1, IN2, IN3 and IN4).

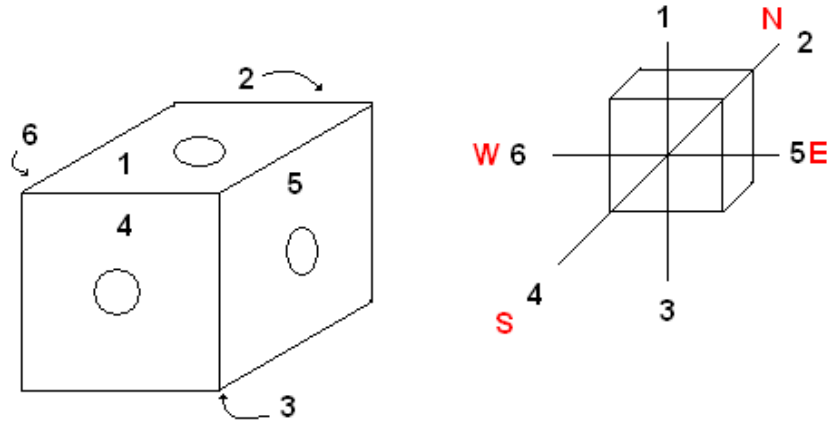


Figure 4: – Dosimeter faces with the numbers that represent the orientation of each face. The face number four is orientated to south, 2 north, 5 east, 6 west, 1 top and 3 to the floor.

3. RESULTS, DISCUSSIONS AND CONCLUSIONS

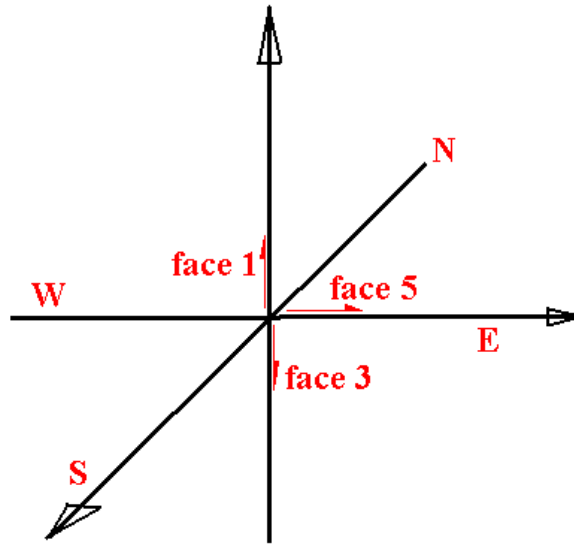
All dosimeters were evaluated and the direction of the major contribution too. These values are in Table 1, that shows the measurement and the contributions of each face.

Table 1: Contributions for the faces in the dosimeters A and B.

Dosimeter A			Dosimeter B		
Dosimeter face	Measurement (nC)	Contribution (%)	Dosimeter face	Measurement (nC)	Contribution (%)
1	3.371	15	1	4.340	16
2	2.332	10	2	2.595	10
3	3.210	14	3	3.229	12
4	6.275	27	4	6.815	25
5	4.372	19	5	3.810	14
6	3.636	16	6	4.224	16

Some faces presented higher values, perhaps, but not conclusive, because they are turned to the radioactive facilities. Hence, it was possible to estimate the direction of the origin of the major contribution of exposure in this area by summing these values, assuming that they are the norm of vectors pointing to each direction (see Figure 5). Doing so, the main component of the resultant vector is pointing to the south direction. This should not be a conclusive

indication that facility IN1 has the main contribution, but could give data to the radioprotection staff work.



**Figure 5: Indication of some vectors (face 1, 3 and 5).
The norm of each vector is the amount measured in the
respective TLD.**

The DD with the face turned to top receives contributions from solar radiation. The face 4 is positioned near nuclear facilities IN1 and IN2 and face 6 is near IN3 and IN4, even these higher values can be considered BG (background) in traditional environmental monitoring already done in this site. The uncertainties associated to the measurements were not superior to 16% [9]. However they were not completely evaluated because this is a preliminary study.

REFERENCES

1. Manzoli J.E; Campos V.P; Moura E. S.; "Directional Radiation Dosimeter for Area and Environmental Monitoring" ,*ENAN* (2007).
2. Rocha F. D. G.; Campos V. P.; Campos L. L."Assessment of the Environmental Exposure at IPEN using CaSO₄:Dy Detectors with Different Filters Combination," *ENAN* (2007).
3. Rogajec-Komor, M.; Thermoluminescence dosimetry-application in environmental monitoring. *Radiation Safety Management*, 2(1), 2-16. (2002).
4. Piesch, E. and Burgkhardt, B.;"Review of environmental and monitoring using solid state dosimeters, and guidelines for technical procedures," *Radiat. Prot. Dosim.*, 5(2), 79-93. (1983).
5. Manzoli J.E; Campos V.P; Doi M.S; - "Monitor Direcional Passivo Ambiental e de Área" (Passive Area and Environmental Directional Monitor); *Comissão Nacional de Energia Nuclear*, -BR Pat. n.PI0405532-2 (in process). 2004

6. (in press) Manzoli J.E.; Campos V.P.; Moura E.S.; "Directional Radiation Dosimeter for Area and Environmental Monitoring," *Arab Journal of Nuclear Sciences and Application*. (2009).
7. Campos, L. L."Development of CaSO₄:Dy dosimeter", *In: Meeting on Radiation Protection Dosimetry*. Itaipava., *Proceeding of meeting on Radiation Protection Dosimetry*., Rio de Janeiro,.v.1.p.2-4. (1983).
8. Manzoli J.E; Campos V.P; "Selecionamento de Detectores de Radiação Segundo sua Sensibilidade e Viabilidade para Dosimetria Termoluminescente," *Metrologia – Metrologia para a Vida* , *Sociedade Brasileira de Metrologia (SBM)*. (2003).
9. Campos V. P.; Dóí M. S.; Manzoli J. E.; "Avaliação do Limite de Repetitividade e de Detecção de Dosímetros de CaSO₄:Dy," *Metrologia - A Metrologia e a Competitividade no Mercado Globalizado*, *Sociedade Brasileira de Metrologia (SBM)*. (2003).