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DOSE RATE MAPPING NEAR THE SOURCES RACKS

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ABSTRACT

The use of the Co-60 Multipurpose Irradiator installed at IPEN – CNEN/SP frequently involves dry static irradiation. This kind of material exposition is needed mainly to research irradiations and to attend customer's requirements. The low number of sealed sources, optimized to the dynamical irradiation, leads to high variations in dose rate on planes that are parallel and close to the sources racks. An empirical dose rate mapping in front of the source racks was made to estimate the time needed to expose the products, and how distant from the source it should be to get the desired dose uniformity. This work presents this dose rate mapping, which is valid for the actual sources distribution, and how it can be used in the dry static irradiations.

1. INTRODUCTION

The Co-60 Multipurpose Irradiator installed in the Radiation Technology Center at IPEN is the compact category IV type and the dynamic irradiation geometry is product overlap sources. The Figure 1 shows how the sources are arranged on the racks in a linear configuration [1].

The ionizing radiation as a industrial tool has the capability of achieving reproducible chemical and biological effects delivering known absorbed doses of radiation. The IPEN semi-industrial gamma irradiation facility is widely used for the radiation processing applications as the medical devices sterilization, the foodstuffs treatment, the polymers modification, wastewater treatment and other applications related to human health [1] [2].

The motivation for the present work was the need to know the dose rates with the Co-60 Multipurpose Irradiator operating in static mode and near of the sources racks. This is justified because the design and the qualification of this Multipurpose Irradiator was established for the machine operating in a mode called Dynamic [1] and, nowadays, due to operational reasons the static mode has been frequently used. For this purpose, experiments were carried out to get the dose rate mapping in air in vertical planes parallel to the source rack and at various distances from the source rack. The regions of maximum and minimum absorbed dose and dose uniformity ratio were determined.

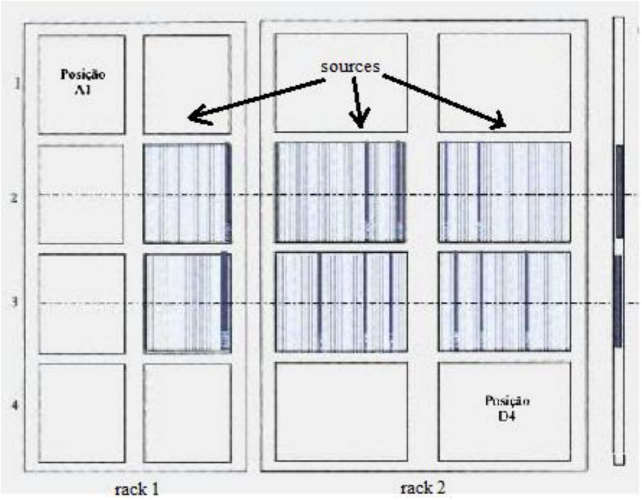

Figure 1. Co-60 sources arrangement.

2. METHODOLOGY AND PROCEDURES

The structures used for the arrangement of the dosimeters were the structures of the containers for dynamic irradiation as shown in Figure 2.

The IPEN Multipurpose Irradiator has two racks sources: the rack 1 with 74 cm and the rack 2 with 148.5 cm of width, respectively. Both are 209 cm height.

The dosimeters for measuring of doses were disposed in a 18.5 cm of width and 16.1 cm of height grids.

It was determined 6 vertical and parallel planes 0 cm, 10 cm, 42.5 cm, 75 cm, 117 cm and 150 cm distant to the sources racks shoulder, in a 14 x 14 dosimeters grid. With these positioning a Cartesian coordinate system was set up, and the dose mapping near the racks included the use of 936 Amber-V dosimeters. Dosimeters placed in the plane to 0 cm of the protectors sources were put directly on it [4]. See Figure 3.

With former irradiation data, we used the following irradiation times: 2 hours for the rack 2 and 4 hours for the rack 1.

The dosimeter used for dose distribution evaluation was the Harwell, UK, PMMA Amber type 3042 batch V, with dose range: 1 to 30 kGy. The doses were evaluated at 651 nm in the Radiation Processing Dosimetry Laboratory of the Radiation Technology Center at IPEN [3].

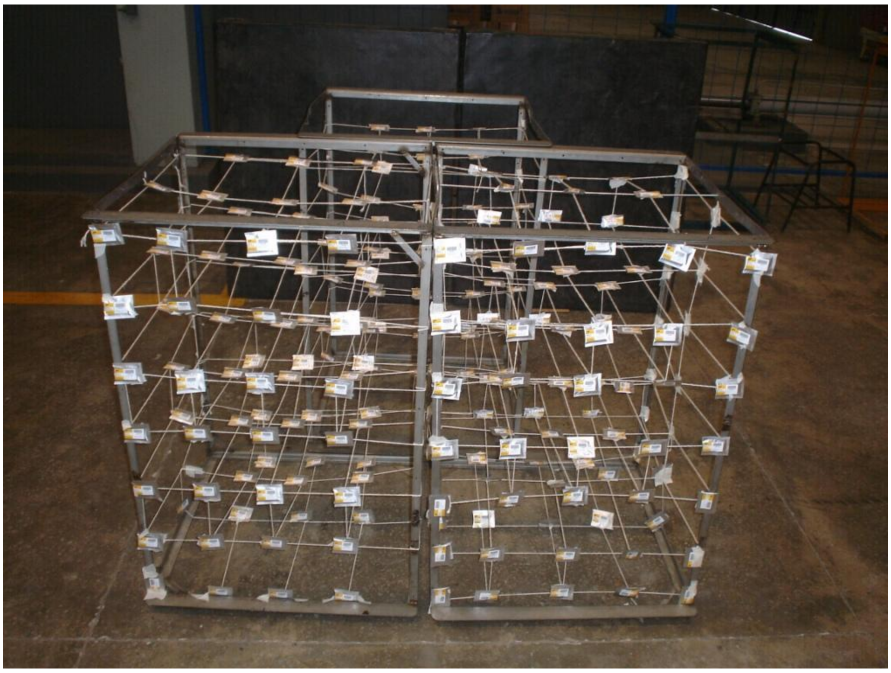

Figure 2. Dosimeters mounted on the structure.

Figure 3. Dosimeters in the irradiation room.

3. RESULTS AND DISCUSSION

Analyzing the results of the dose rates obtained after the dosimeters readings, there was a wide variation in dose rates on the racks of sources. Being farther from the source, a decrease in the dose gradients is observed. See Figures 4, 5, 6 and 7, with dose rates in kGy/h.

In the Table 1 we can observe that the coefficient of variation of dose rate near the racks of sources exceeds 80%, which implies a great heterogeneity of the dose values. This is confirmed by another parameter, the dose uniformity factor, given by the ratio of the maximum dose by the minimum dose (the optimal value is 1). In this case, the variation from lowest to highest value gets to be about 32 times.

When away from the racks, the differences in dose rates are reduced, as presented in Table 1, tending to stabilize from 42.5 cm.

Table 1. Statistics to Rack-2 results.

	Distance			
	0 cm	10 cm	42.5 cm	75 cm
arithmetic average	7.047	4.598	2.760	1.742
standard deviation	5.762	3.159	1.101	0.566
variation coefficient	0.818	0.687	0.399	0.325
variation coefficient (%)	82%	69%	40%	33%
dmax/dmin	31.524	17.735	5.077	4.378

If the front surface of the object to be irradiated has similar dimensions to the front area of the rack, it is better to be placed farther than the distance mentioned above. However, the irradiation time can be long (depending on the dose), because the doses rates are lower.

Table 2. Statistics to Rack-2 results with reduction of the area.

	Distance			
	0 cm	10 cm	42.5 cm	75 cm
arithmetic average	12.870	8.298	3.865	2.328
standard deviation	4.815	1.995	0.676	0.326
variation coefficient	0.374	0.240	0.175	0.140
variation coefficient (%)	37%	24%	17%	14%
dmax/dmin	4.917	2.724	2.055	1.844

On the other hand, if the object to be irradiated covers a surface obtained by removing the rack vertically above and below 51 cm and 34 cm horizontally to the left and right, the results are as presented in Table 2.

With this change, the coefficients of variation and the of dose uniformity factors decrease dramatically, reaching much more acceptable values . You can also use smaller distances, such as 10 cm in this case, as shown in Table 2, the dose uniformities from 10 cm to 75 cm distances are smaller than in the first case (Table 1).

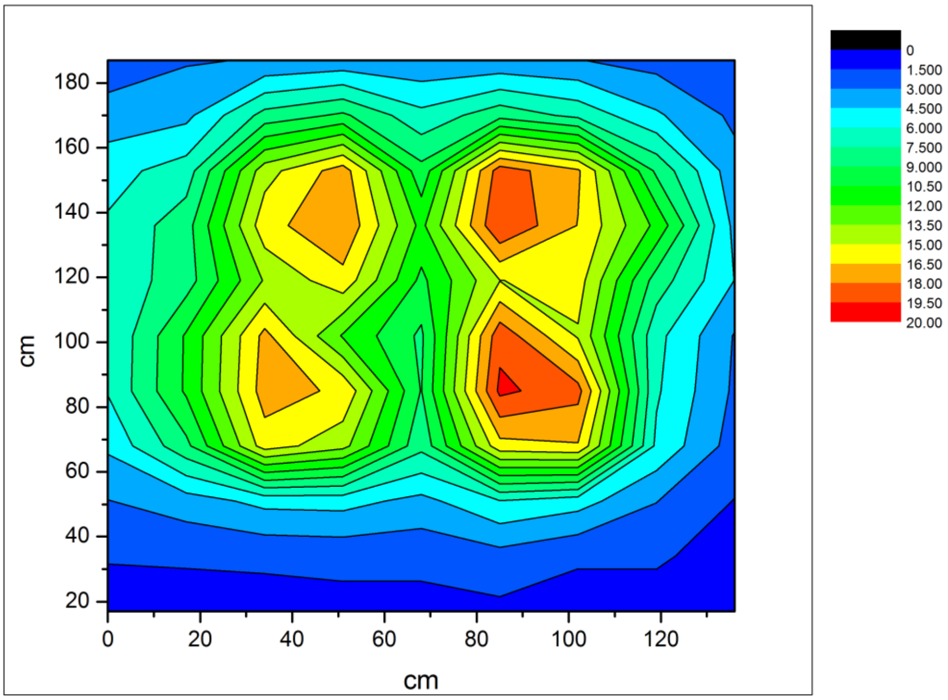

Figure 4. Dose Rates at 0 cm of the racks sources.

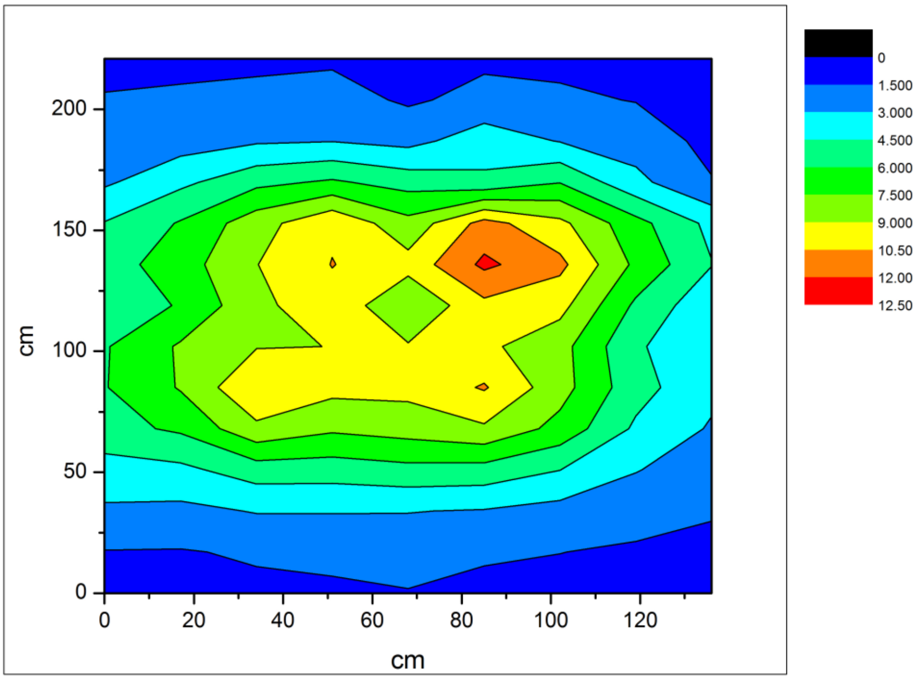

Figure 5. Dose Rates at 10 cm of the racks sources.

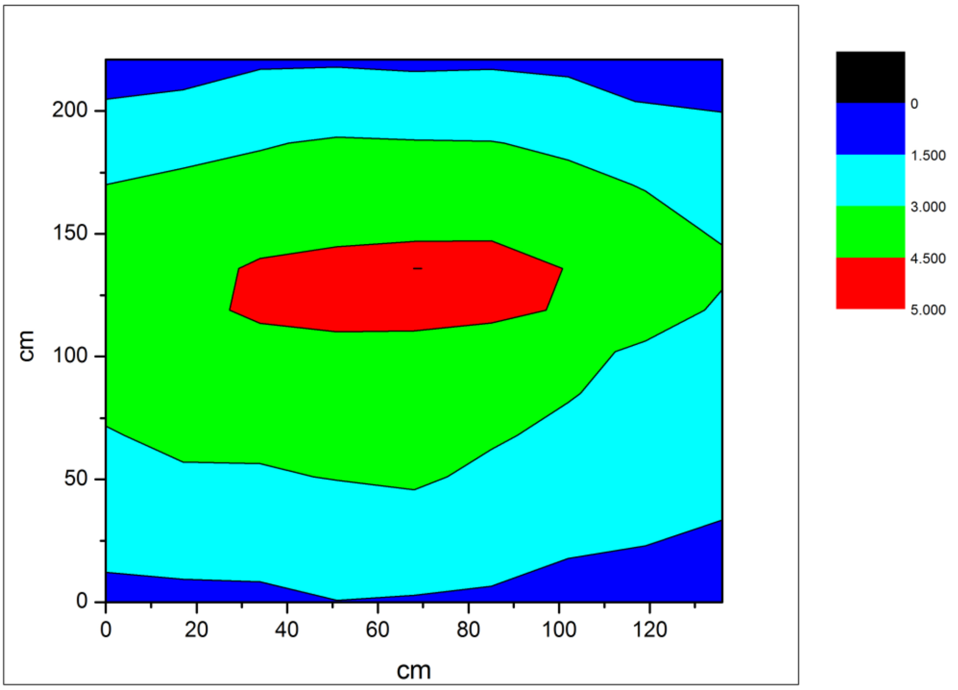

Figure 6: Dose Rates at 42.5 cm of the racks sources.

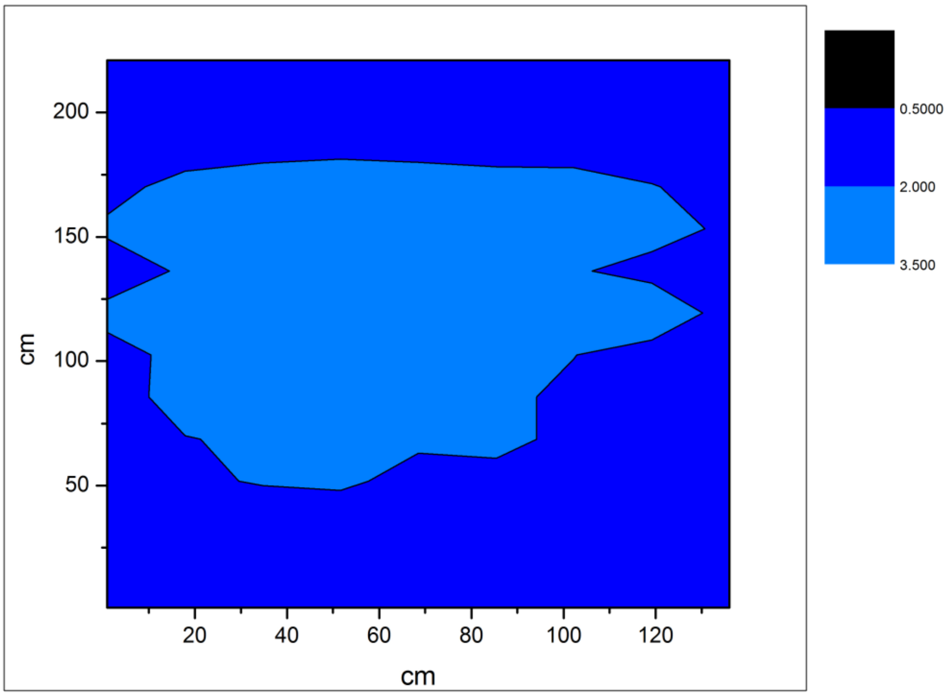

Figure 7. Rates at 75 cm of the racks sources.

4. CONCLUSIONS

This work allows to determine the dose rates around the Co-60 sources rack in order to estimate the time needed to expose the products, and how distant from the source it should be to get the desired dose uniformity. These results may be used as base to perform a more complete and effective dose mapping. Also, it can be used to optimize the static irradiations to the products with different densities with lower amount of dosimeters.

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