Simulation of Occupational Doses in Industrial Radiography

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This report presents a methodology, using the MCNPX code for calculating radiation doses of workers who perform industrial radiography services in urban areas, considering that the dose that a worker may receive as a result of routine operations is usually only estimated, in bulk way, by theoretical and simple methods. The MCNPX code [1] based on the Monte Carlo method is a general-purpose computer program that allows the simulation of radiation transport such as neutrons, photons and electrons, individually or together (coupled) through the matter. This code is used to simulate the transport of nuclear "particles" (photon, electron, neutron and many others). To perform the simulations with the MCNPX code, the geometry used considered that the irradiations were simulated with a source of Ir-192, isotropic point type (4π), monoenergetic of 0.316 MeV, activity of 22 Ci, positioned at 1 m from the axis of a water cylinder (human body), 1.76m high and 30cm in diameter, as a first approximation for a representative model of an adult man [2]. The material used was water, which is dominant material in human tissue. The environment in which the body is was considered dry air. Figure 1 shows the geometry of the investigated model, representing the human body (body) with 3 small spheres with a radius of 1.4 cm, which represent the critical organs: crystalline, thyroid and gonads. In all cases, the simulated energy was the energy deposited per second ($Gy.s^{-1}$). This deposition was calculated both in the body and in investigated organs.

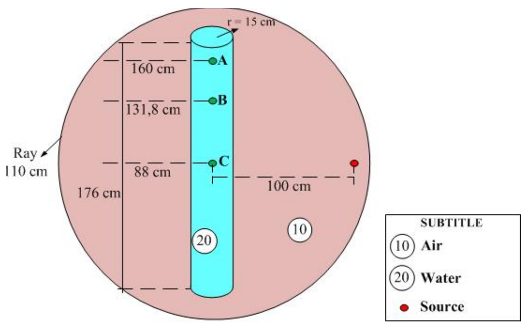

Figure 1. Simulation geometry with MCNPX. Body with 3 organs, all made of water.

The F6 command available from MCNPX code was used to calculate dose in each region. The relative error was estimated to be acceptable by the outline conditions of the code manual with NPS of 2E09. Table 1 shows the results of the simulations performed considering an Ir-192 source, activity of 22 Ci converted from $MeV.g^{-1}$ to $\mu Gy.s^{-1}$.

Table 1 - Dose rate in the body and in the three organs

Dose Rate ($\mu Gy.s^{-1}$)			
crystalline	thyroid	gonads	body
1,15	1,73	2,08	2,85

A study to increase the volume of the gonads was carried out, where only the gonads were considered in the simulation. For both gonads with radius of 1.4 cm and 2.8 cm, the obtained value was 2.08 $Gy.s^{-1}$, while the gonad with 5.6 cm radius the obtained value was 2.2 $Gy.s^{-1}$. It is important to mention that the source-body distance is 100 cm for all simulations. Analyzing the results presented, it is observed that when doubling and quadrupling the gonad radius value, the dose rate values remained practically the same comparing to the energy deposition value previously calculated. The increase in the dose observed in the sphere of radius 5.6 cm is due to the increase in the solid angle together and due to the edge effect. A study to verify this hypothesis is underway, in which a parallel beam of gamma radiation strikes on a water cube. By converting the energy supplied by the MCNPX code, presented in $MeV.g^{-1}$, into an energy unit for $Gy.s^{-1}$, it is possible to calculate and estimate the dose rate to which a worker may be subjected, as a result of operations routine. In a next step, the results obtained by the MCNPX code will be compared with analytical equations and it will be possible to convert the absorbed dose units into an equivalent environmental dose. In addition, this study aimed to acquire knowledge about mathematical simulations using the MCNPX code for the development of a bunker project to be used in industrial radiography.

References:

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