MEASUREMENTS OF AIR KERMA AS FUNCTION OF POTENTIAL IN X-RAY TUBES FOR ESTIMATES STANDARD QUANTITIES USED FOR DOSIMETRIC EVALUATION

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ABSTRACT

Computational Models of Exposure (CMEs) are tools that simulate situations in which irradiation occurs in a given volume. Some of these CMEs have already been produced by the authors both in internal and external dosimetry. From 2008, were published versions of CALDose_X, computational tool developed to organize and present simulations performed with the phantoms of the adult voxels developed at Nuclear Energy Department of Federal University of Pernambuco (DEN-UFPE). The software has been a useful tool for researchers' worldwide due to be a friendly user, contain estimated data with great accuracy and be produced in C #, a modern programming language object-oriented. The CALDose_X presents results to the user who requests information about the dose distribution in a given region of a radiological examination in the format of conversion factors between absorbed dose and a standardization quantity. Information about distribution of absorbed dose need more input from the user: he must inform the software a measured value of the standard quantity to be used. In this work it is raised a curve K x V (K = INAK/mAs; INAK: INcident Air Kerma; KERMA: Kinetic Energy Released per unit Mass, mAs: Work load of the X-ray tube, V: Potential of the tube) to be inserted in CALDose_X in order to obtain the absorbed dose distributions for various examinations. The collection of points obtained is called yield curve of the X-ray machine used. These types of data should be collected whenever a machine is installed or undergoes maintenance. The curve was obtained in the X-ray laboratory of the Regional Center of Nuclear Sciences of the National Commission of Nuclear Energy (CRCN-NE/CNEN) using an X-ray equipment (HF320 of Pantak) and a measurement system consisting of a chamber ionization RC6 of Radcal, calibrated in terms of INAK to the radiodiagnostic qualities (IEC61267), and a Keithley 6517A electrometer. The focus-camera distance used was equal to 1 m. The points (V, K) were obtained for potentials ranging from 50 to 120 kV. It was applied the statistical technique of linear regression for the potential function K=B.VA, transformed to log (K)=log (B)+A.log (V), so that the user can enter the potential and the work load of physical examination required to then the CALDose_X calculate the INAK using the yield curve. Thus, values of absorbed dose in the region of the examination can be saved to a text file. As CALDose_X has a theoretical yield curve, the results of the curve measured in this article were comparatively analyzed. It could say that the experimental arrangement used for the measurements was appropriate, because the yield curve measured for the type of designed X-ray machine, results in a dose distribution in the region of the simulated exam in accordance with the theoretical distribution the software.

Keywords: Computer Models of Exposure, Radiology, C # Programming Language, Absorbed Dose, Air Kerma.

1. INTRODUCTION

In order to assess the dose distributed over an irradiated volume, the research group to which the authors are affiliated has developed several MCEs (VIEIRA, 2004; SANTOS, 2006; LEAL NETO and LOPES FILHO, 2007). The MCEs are utilities that simulate situations in which irradiation occurs in a given medium. They consist basically of: an anthropomorphic model to simulate the geometry irradiated (usually referred to as phantom), algorithms to simulate the radioactive source and a Monte Carlo code to simulate the transport and interaction of radiation with matter, and to evaluate the energy deposited.

In 2008 Kramer et al. have developed CALDose_X software in C # (HARDY et. al., 2008). The current version of this software (available at http://www.caldose.org) is able to compute the INAK based on the yield curve of X-ray tube. With this known quantity is possible to evaluate absorbed doses in organs and tissues for adult male and female phantoms in specific postures by using conversion coefficients D / INAK for more often exams in diagnostic X-rays.

In this paper, the measurement of the yield curve and its points (V, K) were inserted in CALDose_X and the INAK was calculated with specific data. So, dosimetric evaluations were made for an examination of diagnostic radiology based on this curve. A yield curve in the CALDose_X consists of air kerma values per mAs at 1 meter of the target as function of the potential of the X-ray tube. The measurements were performed in the X-ray laboratory of CRCN-NE/CNEN in Recife, Pernambuco, Brazil, using an experimental arrangement suitable for industrial X-ray machines.

Since it is not possible to measure locally the absorbed dose in organs and tissues of the human body, the radiation protection quantities are useful for dosimetry evaluation. Robust Monte Carlo codes such as EGSnrc (KAWRAKOV et. al., 2009) allow the estimation of conversion coefficients (CCs) between absorbed dose and a radiation protection quantity. Knowing the value of the quantity, for example, INAK, it can be estimated an equivalent dose (equal to absorbed dose for electrons and photons) on the radiosensitive organs and tissues as well as the effective dose. Hence the importance of measures such as those made in this article and in softwares such as CALDose_X.

2. MATERIALS E METHODS

Softwares like CALDose_X are very useful in radiodiagnostic planning because they provide an estimate of the absorbed dose in the irradiated region and assess the risks as a result of irradiation. Thus, if more realistic data are provided for computation of the required radiation protection quantities to estimate the distribution of absorbed dose, more reliable will be the values printed in the report obtained by the user.

The yield curve presented in this paper was obtained in the X-ray laboratory CRCN-NE/CNEN using an X-ray equipment (Pantak HF320). The measurement system consisting of a Radcal RC6 ionization chamber, calibrated in terms of INAK to the radiodiagnostic qualities (IEC61267), and a Keithley 6517A electrometer. The focus-camera distance used was equal to 1 m. The points (V, K) were obtained for potentials ranging from 50 up to 120 kV. This collection of points was inserted in CALDose_X to obtain the function K = f (V). The software applies the statistical technique of linear regression for the potential function $K=B.V^{A}$, transformed to log (K)=log (B)+A.log (V) in order to obtain the parameters A and B of the curve. When the user enters, in the input window of the software CALDose_X, the potential and the workload of required physical examination, then the software calculates the INAK using the yield curve available.

RESULTS AND DISCUSSION

Table 1 shows the theoretical curves K x V obtained in the laboratory of CRCN-NE/CNEN.

Table 1: Yield Curves

Potential (kV)	K (µGy/mAs) CALDose_X	µK (µGy/mAs) CRCN-NE/CNEN
50	41.29	32.41
60	60.93	48.45
70	80.98	65.61
80	102.42	82.49
90	125.16	105.00
100	148.85	125.61
120	198.46	170.87

Logarithmic graphs in Figure 1 shows, besides the curves, the functions obtained K = f (V).

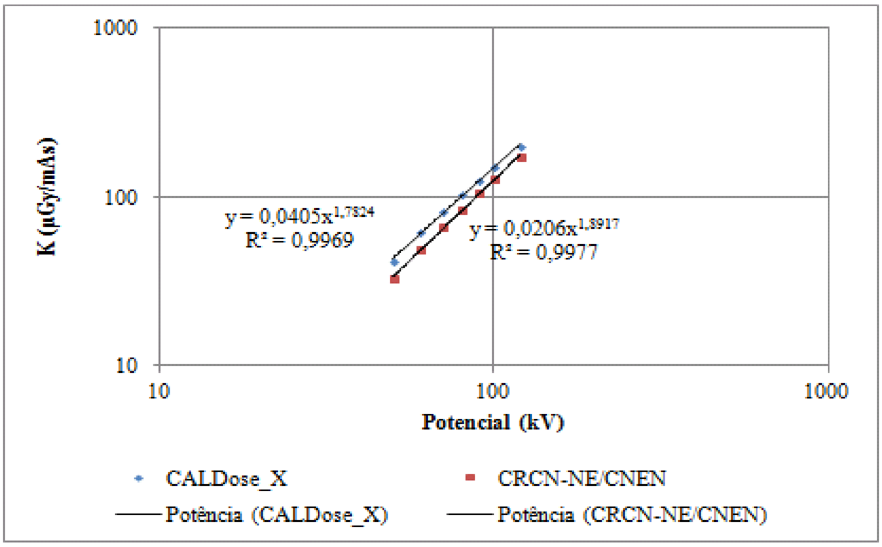

Figure 1: CALDose_X yield curve and that obtained in the laboratory of CRCN-NE/CNEN.

The values of the squared correlation coefficient for the two curves show that the potential function is suitable for this type of modeling. As the values entered by default in CALDose_X are theoretical, each user of the software needs to get your own curve as done here.

Figure 2 shows the window of the CALDose_X, where are inserted the data of the new curve. Thereafter, one can obtain the estimated absorbed dose for the different exams available in the software, using the INAK calculated with the curve and the other input data given by the user.

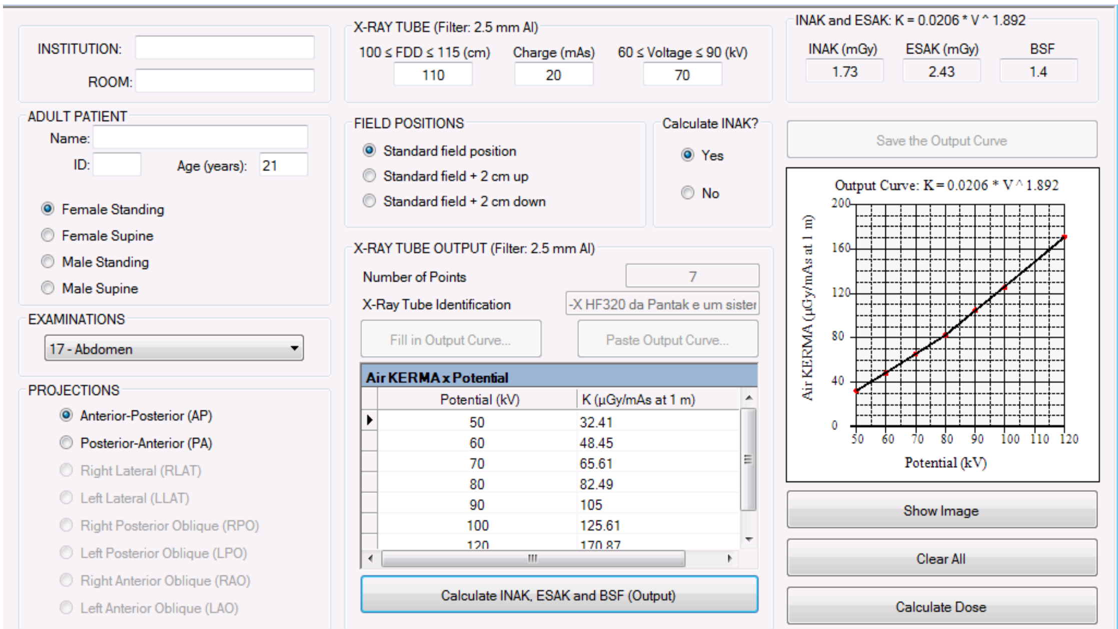

Figure 2: Insertion of the measured yield curve in the CALDose_X.

With the data shown in Figure 2, varying the projection and the focus-detector distance (FDD), the Tables 2 and 3 were obtained as dosimetric results for the abdomen examination.

Table 2: Dosimetric results for the AP projection of the abdomen examination.

	ABSORBED DOSE (mGy)		
FDD (cm)	**BLADDER**	**LUNGS**	**PANCREAS**
100	0.11	0.13	0.70
105	0.10	0.12	0.63
110	0.09	0.11	0.56
115	0.09	0.10	0.51

Table 3: Dosimetric results for the PA projection of the abdomen examination.

	ABSORBED DOSE (mGy)		
FDD (cm)	**BLADDER**	**LUNGS**	**PANCREAS**
100	0.13	0.11	0.30
105	0.12	0.10	0.27
110	0.12	0.10	0.25
115	0.11	0.09	0.23

With a custom yield curve, the CALDose_X user can obtain dosimetric results for the examination of interest and choose the parameters with more accuracy to be used in therapy.

4. CONCLUSIONS AND PERSPECTIVES

In this paper was obtained the INAK curve as a function of the potential of an industrial X-ray machine. The points of this curve were entered into the software CALDose_X for dosimetric assessments of specific diagnostic exams. The results show that the curve was measured and properly inserted into the software. These curves should be obtained by radiologists who wish to use the CALDose_X or similar software to customize your work machine.

New curves will be obtained to dental X-rays and all the computational data organization, the graphical analysis and the numerical results will be implemented in specific software to be developed in future studies.

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