Construction of an ionization chamber for the measurement of dose of low energy x-rays

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Abstract. We designed and constructed the prototype of an ionization chamber to measure the dose of an X-ray tube with Molybdenum anode. This X-ray tube is located in the Physics department at CINVESTAV and is used for medical physics purposes in the imaging area. The ionization chamber is designed to measure doses on biological samples exposed to X-rays and will be applied in radiation protection studies.

INTRODUCTION

The measurement of the effect of radiation on living beings is important in several medical applications like X-ray diagnostic, nuclear medicine, Radiotherapy, etc. The principal quantity of interest in these cases is the energy deposited per unit mass, which is known as absorbed dose.

Since the mechanism for transfer of energy from radiation to matter involves the ionization processes caused by primary radiation, ionization chambers play a central role in the measurement of radiation effects.

Because of its simplicity of operation, the ionization chamber is a very versatile instrument. It can be designed in many sizes and shapes and can be employed to measure all types of radiation that produce either primary or secondary ionization, for example, in nuclear medicine, ionization chambers are generally used to determine the exact activity of radioactive substances and are called dose calibrators of radioisotopes.

The designed ionization chamber is intended to be used in the measurement of dose in X-rays image applications in Mammography.
PRINCIPLES OF OPERATION

Our ionization chamber in its simplest form, essentially consist of two parallel-plates, and a circuit which measures the current flow. The electrode to which the measuring instrument is attached is referred to as collecting electrode. The other electrode is held at a potential above ground by means of the battery, this electrode is sometimes called the high-voltage electrode.

The collecting electrode is supported by an insulator, there is also another electrode known as the guard electrode or guard ring. The guard electrode is maintained at a potential near to the collector potential, the electrodes are supported by a very good insulator. One of the functions of the guard ring is to shape the electric field near the edges of the collecting electrode, thus defining accurately the volume from which ionization is collected. This volume is known as the sensitive or active volume of the chamber. The filling gas inside the ionization chamber is air at atmospheric pressure.

The ionization of gas by nuclear radiation consists of the removal of one or more electrons from a number of gas molecules; thus positive ions and free electrons are formed. The behavior of these charged particles after formation depends on the conditions within the chamber, including the electric field. The schematic diagram and the assembled parallel-plate ionization chamber are shown in Figure 1.

**FIGURE 1.** Schematic diagram and prototype of the parallel plate ionization chamber.

Our chamber was designed to measure absorbed dose in biological samples exposed to low energies X-rays, principally for the measurement of radiation generated in an X-ray tube with anode of Molybdenum to be used in the Radiology Laboratory of CINVESTAV of Mexico City.
MATERIALS AND ASSEMBLY

The materials used in the construction of this chamber were:
High voltage electrode (Aluminum Plate, 70 mm X 70 mm x 3 mm with circular window of 25.4 mm of diameter), Collecting Electrode (Aluminum Plate, 70 mm X 70 mm X 3 mm), Guard Ring (Copper Plate, 70 mm X 70 mm X 0.25 mm with window of 50 mm X 50 mm), Insulator 1 (Teflon Plate, 70 mm X 70 mm X 2 mm with a window of 50 mm X 50 mm), Insulator 2 (Teflon Plate, 70 mm X 70 mm X 7 mm with a window of 50 mm X 50 mm), Circular Mylar window, 25.4 mm of diameter with 0.0025 mm of thickness, One BNC connector, One high voltage connector.

The assembly of our ionization chamber is shown in the Figure 2.

EXPERIMENTAL SET UP

The ionization chamber is put at 15 cm from the focal point of the X-ray tube, it is biased with a voltage power supply at 90 V. The ionizing current is measured with an electrometer. See Figure 3.
RESULTS

The saturation voltage of the ionization chamber was obtained experimentally, thus, the operating voltage was selected at 90 V. The operation of the ionization chamber was verified by applying beams from the X ray tube. The obtained values are shown in the Figure 4 and Figure 5. This values shown good agreement with results obtained with a commercial ionization chamber which was designed for low energy X-ray fields.

**FIGURE 4.** Saturation curve of the ionization chamber.

**FIGURE 5.** Response for different tube currents and accelerating voltages.
CONCLUSIONS

The designed ionization chamber was built and tested under laboratory conditions, the obtained results show a good behavior if compared with similar commercial units available on the market. This device is the basis for future improvements in the development of ionization chambers and could be used in new applications of interest in Medical Physics in Mexico.

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REFERENCES