Development of Cavity Chambers for the measurement of air kerma in the Metrology Laboratory of Ionizing Radiation

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The effects of radiation on matter depend on the radiation field, described by radiometric quantities, and on the interactions between radiation and matter, described by interaction quantities. Dosimetric quantities are products of the first two.

Radiation interacts with matter in a series of processes of conversion and deposition of energy, with quantities characterizing each of the two stages.

Conversion of energy refers to the transfer of energy from ionizing particles to secondary ionizing particles. The quantity kerma pertains to the kinetic energy of the charged particles liberated by uncharged particles. In conditions of charged-particle equilibrium, kerma serves as an approximation to absorbed dose for uncharged ionizing particles. It allows, for example, in the context of the metrology laboratory, the determination of the operational quantities of radiation protection for application of conversion coefficients. This is one of the aspects illustrating the importance of the air kerma standards.

Graphite cavity chambers are the most commonly used instruments to measure air kerma rates in the energy ranges of ^{137}Cs and ^{60}Co. The development of cavity chambers is a challenge with options to be taken with respect to:

(i) the best geometry, cylindrical or spherical shaped, with influence on the electric field and determination of the dead zone in the inner volume;

(ii) the electrical connections and insulation, with influence on the definition of the active volume and the quality of the electric signal.

The air kerma is determined using cavity theories. However, it's necessary to introduce a number of correction factors that account for atmospheric, electrical, or detector perturbation corrections. These factors can be determined either experimentally and/or using well established Monte Carlo simulation codes, such as MCNPX, PENELOPE and EGSnrc.

The final result of the measurement must be stated with its associated uncertainty. An innovation in this field is the use of Monte Carlo methods to calculate the several components of uncertainties.

After the experimental tests to the working conditions of the chamber, a bilateral comparison between IST/ITN and LNE-LNHB (our collaborator in this project) primary references is expected. The final goal is to provide IST/ITN with a home-made national primary standard for ^{60}Co and ^{137}Cs, after a key comparison with the BIPM.