CHARACTERIZATION OF CS-137 BEAM USED FOR CALIBRATION OF RADIATION PROTECTION INSTRUMENTS

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Abstract

Secondary Standard Dosimetry Laboratory (SSDL) at the Department of Radiation Protection and Monitoring Networks (Institute of Applied Nuclear Physics, University of Tirana), provides traceability route to SI units for the radiation measurements within the country at radiation protection level. SSDL belongs to the International Network of SSDL, organized by International Atomic Energy Agency (IAEA) and the World Health Organization (WHO). The aim of this work is the experimental characterization of the radiation beam produced by the Cs-137 source used for the calibration of radiation protection instruments. The available measured air-kerma rates ranged between 1.6 μGy/h and 43.7 mGy/h. A set of lead blocks was used to attenuate the beam in order to cover all range requested for the calibration. Radiation protection instrument calibrations provided by SSDL are checked through the participation in international intercomparison activities organized by IAEA where the National SSDL has achieved satisfactory results. This work shows that a single beam used with proper attenuators enabled the calibration within an acceptable accuracy at a wide range of air-kerma rates, which are requested for calibration of radiation protection instruments.

Key words: radiation protection, instrument calibration, SSDL, dose rate.

Introduction

The radiation instruments must be calibrated prior to its first use and subsequently recalibrated periodically at standard reference radiation (IAEA, 2000). Calibration services to users and traceability of radiation dosimetry to national and international standards for users within the country are provided by a national Secondary Standard Dosimetry Laboratory (SSDL).

The duty of a national SSDL, at the level of ionizing radiation protection, in Albania is performed by SSDL in the Department of Radiation Protection and Monitoring Networks, Institute of Applied Nuclear Physics (IANP), University of Tirana. This laboratory was founded and operates since 2004, through a Technical Cooperation Project with the International Atomic Energy Agency (IAEA) (Dollani *et al.,* 2009). SSDL is a member of the International Network of SSDL, organized by IAEA and the World Health Organization.

According to the recent international protocols, Cs-137 emits a good quality beam for calibration in the range of radiation protection (Mohamed *et al.,* 2017). In this work the Cs-137 beam at the IANP is characterized in terms of air-kerma rate in order to be used in radiation instruments calibration at protection level and for SSDL participation in international intercomparison activities organized by IAEA. As a various types of protection level radiation instruments are used in Albania, a set of

lead blocks was employed to attenuate the beam in order to cover all ranges requested for the calibration.

Materials and methods

The SSDL equipment is calibrated towards Primary Standards Dosimetry Laboratory (PSDL) at IAEA. The laboratory occupies two rooms: the irradiation room and the control one. In the irradiation room are located the radioactive source Cs-137, the ionizing chamber LS-01, the ventilation-air conditioning system, calibration stands and other measurement support equipment (Figure 1).

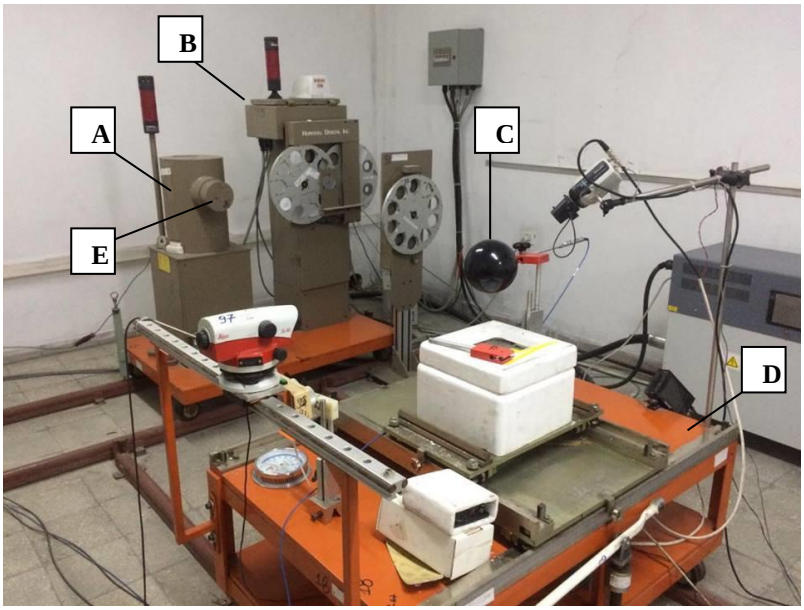


Figure 1. LDSS irradiation room: A: Cs-137 source, B: X ray machine, C: the ionizing chamber LS-01, D: calibration stand, E: Lead block

The control panel, the electrometer UNIDOS (PTW) and monitors, coupled with video cameras in the irradiation room, are placed in control room.

In order to protect the staff and surroundings against radiation, the rooms are separated by a reinforced concrete wall of 50 cm thickness and a plated door with 2cm thick lead layer. Safety devices are also installed on the door and give a signal during the time of the radiation process. By means of the electrometer UNIDOS is measured the electrical charge accumulated in the ionization chamber during the unit of time of irradiation.

Subsequently, the value of the electrical charge accumulated is transformed into air-kerma rate $K'_{air,}$ taking into account the calibration coefficient of the

electrometer, determined by PSDL, given in terms of air-kerma per charge unit: (25.6 ±0.2) μGy/nC. The result is corrected to the standard conditions of air temperature of 293.15^0 K and atmospheric pressure of 101.325 kPa, based in the ambient temperature and pressure (Pernicka *et al.*, 1999, Dollani *et al.*, 2009). The measurements are performed in ambient temperature of 298^0 K and atmospheric pressure of 993.6 mbar.

Results

National standard of radiation

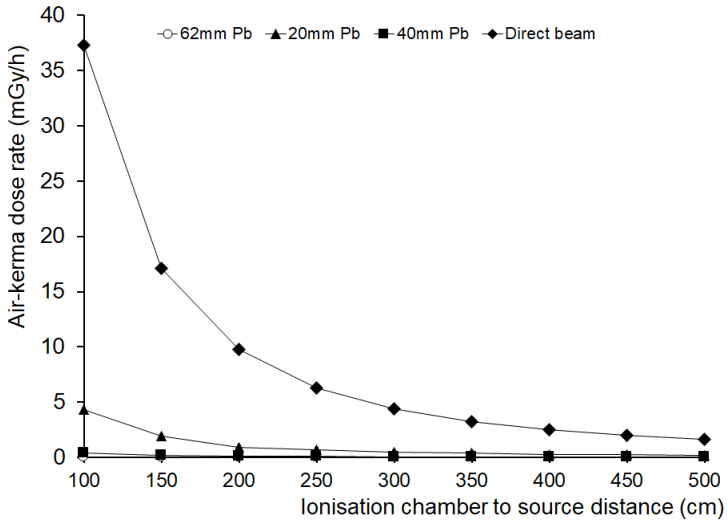
The ionizing chamber LS-01 was placed 1m from the geometric centre of the Cs-137 source and was directly irradiated. By means of the electrometer UNIDOS was measured the electrical charge accumulated in the ionization chamber during the unit of irradiation time. The mean value of the electrical charge accumulated was: 23.672 ±0.2 nC; this value was transformed into air-kerma dose rate (Dollani *et al.*, 2009) and the result was K'_{air}=37.3mGy/h.

The value of the air-kerma dose rate measured as described above determines the national standard of radiation which was used as reference for calibration of radiation protection instruments.

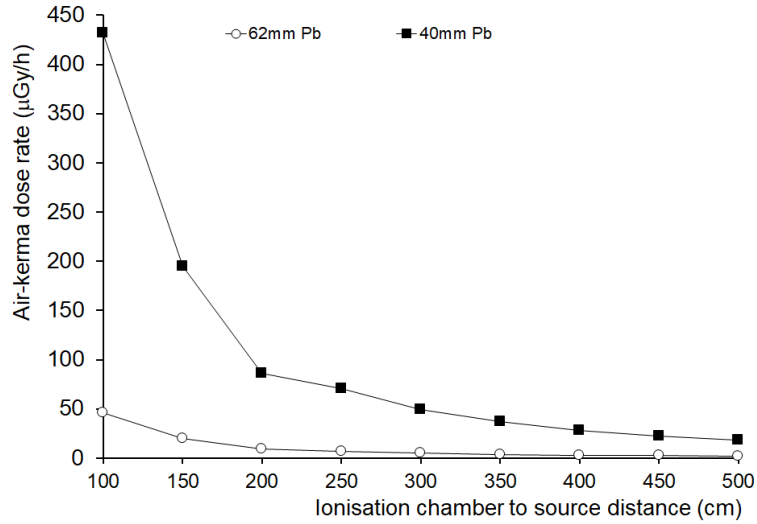
Dosimetry of Cs -137 Beam

In order to cover the ranges of air-kerma dose rate lower than the national standard of radiation, it was needed to use the lead attenuators. The ionizing chamber LS-01 was placed from 1 to 5 m (with step of 50 cm), from the geometric centre of the Cs-137 source and was irradiated with direct beam and with attenuated one. In order to attenuate the Cs-137 beam, three lead blocks of 127mm diameter and of different thicknesses (20mm, 40 mm, 62mm) were placed on the holder in front of the exposure window (Figure 1).

The values of the air-kerma dose rate for each position, without and with each of the three lead attenuators are represented in Figure 2A. The values of air-kerma dose rate obtanied when using 40mm and 62mm lead are not clearly visible in Figure 2A as are low. The plots of air-kerma dose rate obtanied when using 40mm and 62mm lead are visible in Figure 2B.



A)



B)

Figure 2. Air-kerma dose rate values for Cs-137 source: A) direct beam and with 20mm, 40mm and 62mm Pb B) with 40mm Pb and 62mm Pb

Intercomparison audit

The national SSDL has participated recently in the radiation protection level intercomparison audit run organized by IAEA, in order to verify calibration process provided by SSDL at the quality of Cs-137 beam. The national standard value of radiation was used to calculate the nessessary time to irradiate the OSL dosimeters send by IAEA with a known dose of 5 mGy. After irradiation the OSL dosimeters were returned to IAEA PSDL for evaluation. The results of intercomparison quality audit for our national SSDL were within the acceptable limits of ±7% set by IAEA PSDL for the participating laboratories.

Discussions and conclusions

In this study, the Cs-137 source beam of the national SSDL, used for the calibration of radiation protection instruments, was experimentally characterized in terms of air-kerma dose rate. Figure 2 shows that the use of lead blocks of different thinkness can reduce the air kerma dose rate of Cs-137 beam from 37.3mGy/h to 1.6 μGy/h.

The doses at any other distances, nedeed for the calibration of radiation protection instruments, can be calculated by inverse square law, taking as e reference the national standard of radiation.

Based on the results of this characterization, the SSDL has participated in the radiation protection level audit organized by IAEA, where the results were well within the acceptance limit set by IAEA.

This study showed that the national SSDL equipped with a Cs-137 source, used with proper attenuators, enabled the calibration within an acceptable accuracy at a wide range of air-kerma rates, which are needed for calibration of radiation protection instruments. This is an important result, especially due to the fact that this laboratory is the only national SSDL which serves Albania and Kosovo.

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