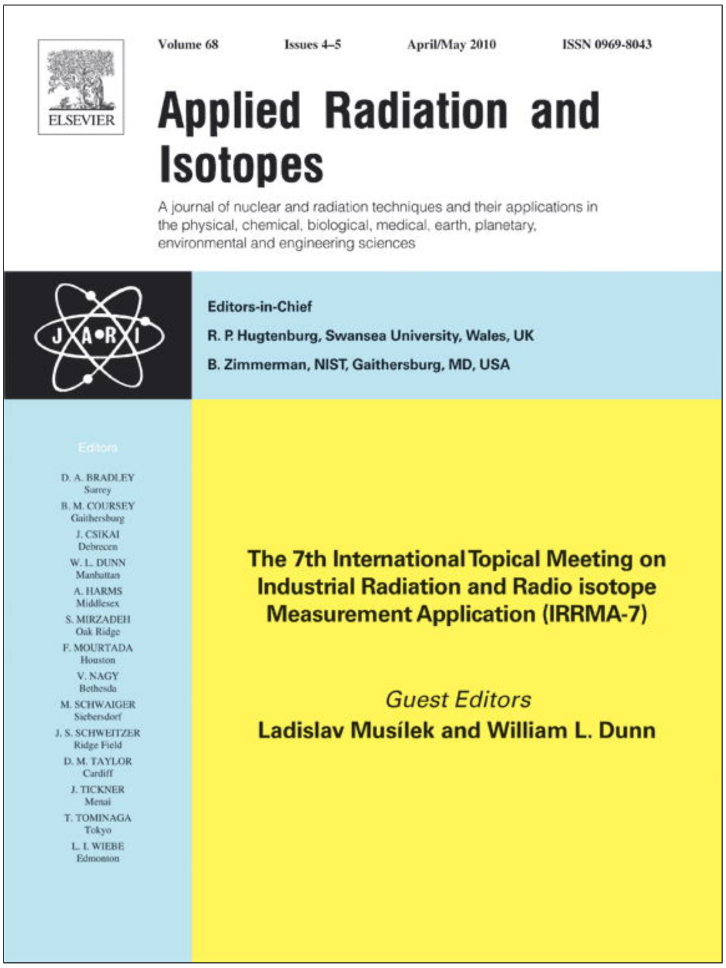

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Evaluation of the planar sources surface homogeneity used to instruments calibration

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ABSTRACT

The surface homogeneity of planar sources used to calibrate contamination detectors is important considering that their dimensions are bigger than the most kind of detectors tested and the positioning in relation to the source may vary in each measurement. Using a special pancake detector the counting efficiency of alpha and beta sources was measured in several positioning covering all area of the sources. The ^{14}C source showed the worse performance and the ^{241}Am source showed the best behavior.

1. Introduction

The Calibration Laboratory of IPEN acts in the Radiation Protection, Radiation Therapy, Nuclear Medicine and Diagnostic Radiology areas, using special set-ups with gamma and beta radiation sealed sources, alpha and beta radiation planar sources and low and intermediate energies of X radiation. The procedures follow international recommendations (IAEA, 2000a, 2000b; IAEA, 2007). About 200 instruments used in nuclear medicine clinics to detect surface radioactive contamination are calibrated annually. These kind of instruments are pancake type Geiger tubes with very thin mica windows (2 mg cm^{-2}). They usually are sensitive to beta particles, with energies greater than 40 keV. They can also detect energetic alpha particles and gamma-rays. However, in this case the efficiency will be very different depending on the different radionuclides. The counting efficiency also depends on how close to the contaminated surface the detector is held. Surface contamination is usually expressed in units of radioactivity per area unit (Bq/m^2) (ISO, 1988). Other units such as picocuries per 100 cm^2 or disintegrations per minute per square centimeter are sometimes used.

The surface homogeneity of these sources is an important task, considering their dimensions of 100 × 150 mm, which is bigger than the most kind of detectors tested, usually they have about 15.0 cm^2, and the positioning in relation to the source may vary in each measurement.

The objective of this work is to measure the counting efficiency of the sources (from Amersham Buchler GmbH & Co KG) using only one special pancake detector (for alpha and beta radiations) assigned to the sources quality control.

2. Materials and methods

The analyzed calibrated plane beta and alpha sources are used in special set-ups to do calibrations. Their characteristics are showed in Table 1. They were calibrated at the Bureau International des Poids et Mesures with an uncertainty of ±5% (September 1989). The gamma emissions of the radioactive sources tested were not considered in this paper (less than 0.1% of the total radioactive source emissions). In the measurements performed the estimated uncertainties were ±11,2%.

To measure the counting efficiency of the sources it was used a Thermo detector, model FH40GX whit a pancake probe model FHZ732GM, specially acquired to sources quality control. The set-up used to do measurements and the detector used are in Fig. 1.

As the area of the probe, 15.5 cm^2, is smaller than the sources area, 150 cm^2.The measurements were made in several positioning covering all area of the sources, divided in 9 small areas. The schematic diagram of the set-up can be seen at Fig. 2. Each

Table 1
Main characteristics of the plane sources of alpha (^{241}Am) and beta (^{14}C; ^{16}Cl; ^{90}Sr+^{90}Y) radiation.

Source	Emission rates (s^{-1})	Area (cm^2)	Reference date	Half-life (year)
^{241}Am	442	150	11/26/96	432.7
^{14}C	406	150	11/26/96	5730
^{99}Tc	572	150	12/13/96	214000
^{137}Cs	586	150	01/14/97	30.15
^{36}Cl	643	150	01/14/97	301000
^{90}Sr	1300	150	11/26/96	28.15

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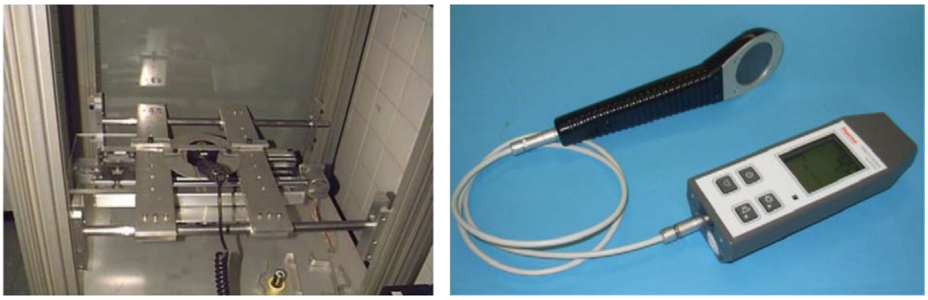

Fig. 1. Special set-up to positioning the detector in calibration and probe connected to the detector to measure the sources homogeneity.

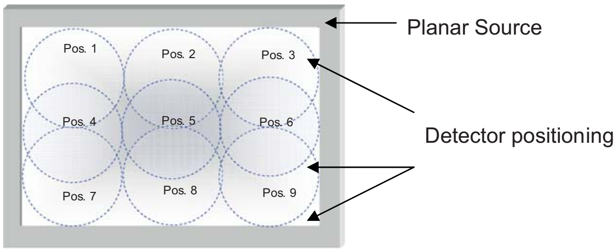

Fig. 2. Schematic diagram of the positioning of the detector in the surface of the sources. Each position corresponds to 15.5 cm^2.

Table 2
Counting efficiency encountered in each one of the 9 positions in the area of the sources.

Detector position	^{241}Am	^{14}C	^{99}Tc	^{137}Cs	^{36}Cl	^{90}Sr
1	0.41	0.15	0.33	0.47	0.52	0.49
2	0.39	0.12	0.36	0.51	0.57	0.58
3	0.41	0.34	0.33	0.47	0.47	0.48
4	0.41	0.17	0.35	0.44	0.49	0.55
5	0.40	0.18	0.35	0.53	0.47	0.55
6	0.40	0.40	0.32	0.46	0.40	0.47
7	0.40	0.16	0.34	0.41	0.46	0.52
8	0.38	0.18	0.32	0.44	0.45	0.56
9	0.38	0.24	0.30	0.42	0.40	0.50
Maximum variation (%)	**7.3**	**70**	17	23	30	19

position corresponds to the area of the detector. The distance detector-source was 3.0 mm in all cases. It was made 10 reading in each positioning, as an usual calibration.

3. Results

The results showed a large variation in the detector responses depending on its position in relation to the source surface. The worse performance showed the non-homogeneity of the ^{14}C source with 70% of variation between the measurements, while the best behavior was of the ^{241}Am source with homogeneity of 7.3%. The other sources presented results between 17 and 30% of homogeneity. Those values can be observed in Table 2.

The regular calibrations are often made in the center of the source near the position 5. However the areas probes may vary, so it is important to correct all the measurements.

4. Conclusions

These results indicate the necessity of a better specification for source homogeneity of the planar sources must be given to the manufacturer, to a laboratory, to minimize that non-homogeneity, mainly when those sources will be used to calibration procedures in order to know the surface emission rates in the right position where the detector is placed during the measurements. The source with a 70% of non-homogeneity must be replaced or not to be used to do calibration any more. To avoid that non-homogeneity in the planar sources, it is important to perform a periodically scan of that with a radiation detector with adequate probe (small size) in whole surface of that sources.

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References

International Atomic Energy Agency, 2000a. Absorbed dose determination in external beam radiotherapy. IAEA, Technical Reports Series No. 398, An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water, Vienna.
International Atomic Energy Agency, 2000b. Calibration of radiation protection monitoring instruments. IAEA, Safety Report Series No. 16, Vienna.
International Atomic Energy Agency, 2007. Dosimetry in diagnostic radiology: an international code of practice. IAEA, Technical Reports Series No. 457, Vienna.
International Organization for Standardization, 1988. Reference sources for the calibration of surface contamination monitors—Beta-emitters (maximum beta greater than 0.15 MeV) and alpha-emitters. ISO 8769, Switzerland.