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QUALITY CONTROL TESTS OF TWO MONITOR IONIZATION CHAMBERS USING DIFFERENT TYPES OF IONIZING RADIATIONS

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ABSTRACT

According to the recommendations published by the International Electrotechnical Commission (IEC 61674), about dosimeters with ionization chambers and/or semi-conductor detectors as used in X-ray diagnostic imaging, there are some quality control tests that must be performed in the equipment to define their characteristics and assure their correct operation. In this work, two different ionization chambers used as monitor chambers, a Farmer type chamber and a transmission chamber, were tested using a stability check device ($^{90}Sr + ^{90}Y$) and an X-ray generator. Three tests were realized: leakage current, repeatability and long term stability. The leakage current was negligible for both chambers, considering the minimum effective air kerma rate of the range in which the chambers are usually utilized. The repeatability of the response of both chambers was within the limits recommended by the IEC report. Although the long term stability results were also within the limits recommended in all cases, it was observed that the deviation obtained was lower with the use of X-rays than with the check device. The maximum deviations determined were 1.34% and 1.11%, using respectively the check device and X-rays.

1. INTRODUCTION

All radiation detectors must present a satisfactory performance to assure a correct diagnosis. It includes all equipment used in calibration laboratories once they are used as reference systems. The recommendations of the International Electrotechnical Commission (IEC 61674) are utilized to evaluate the performance of the dosimeters with ionization chambers and/ or semi-conductor detectors as used in X-ray diagnostic imaging [1].

The monitor ionization chambers are used whenever the stability of the radiation generator is not assured, and their response allows another method to correct the main chamber measurements. For X-ray applications, the monitor chamber frequently used is the transmission ionization chamber. It presents plane-parallel electrodes, and it is utilized fixed in front of the X-ray tube exit, covering the whole radiation field. For these reasons, this ionization chamber must not interfere with the direct radiation field, and it shall present good response stability. A cylindrical Farmer-type chamber can also be used as a monitor chamber. In this case, it is localized outside the direct radiation field, in the penumbra region.

The stability of these monitor ionization chambers can be checked performing some quality control tests described in the IEC Report 61674 [1]. These tests are: determination of leakage current, repeatability and long term stability of the chamber response.

2. MATERIALS

In this work two ionization chambers used as monitor chambers were submitted to quality control tests using two different types of ionizing radiations. The ionization chambers were: a cylindrical Farmer-type ionization chamber, *Nuclear Enterprises,* NE, model 1229, with a 0.6 cm^3 sensitive volume; and a transmission ionization chamber, *Physikalisch Technische Werkstätten,* PTW, model 34014, with a 86.0 cm^3 sensitive volume. These chambers were connected to PTW electrometers, models UNIDOS and UNIDOS E, respectively.

The tests were performed using check devices of $^{90}Sr + {}^{90}Y$ and a standardized X-ray generator, radiation quality RQR 4, diagnostic radiology level, that corresponds to 60 kV, 10 mA and total filtration of 2.5 mmAl (according to the IEC Report 61267 [2]). The check devices utilized in these tests were different for each chamber. They were two PTW check devices, model 48002, with nominal activity of 33.3 MBq (1996), used with the cylindrical Farmer-type chamber; and model S1253, with nominal activity of 11.1 MBq (1976), used with the transmission chamber. The Farmer-type ionization chamber and the transmission chamber were positioned at 50 cm and 30 cm from the focal point, respectively. The air kerma rate (at the distances of 30 cm and 50 cm) were 407.9 mGy/min and 143.5 mGy/min, respectively.

3. RESULTS

3.1. Leakage current test

To perform the leakage current test, the chambers were previously irradiated, and the charge produced was accumulated for 1 minute. After 20 minutes, without irradiation, the accumulated charge was measured again. The leakage current was determined in terms of coulomb/ minute, and it shall not be higher than 5% of the minimum effective air kerma rate [1].

For the Farmer-type ionization chamber, the leakage current was measured right after the measurements for the repeatability test. The maximum value of leakage current was 0.03% for both ionization radiations. For the transmission ionization chamber, the maximum leakage currents measured were 1.71% and 0.02%, respectively using the check device and the X-ray generator.

3.2. Repeatability test

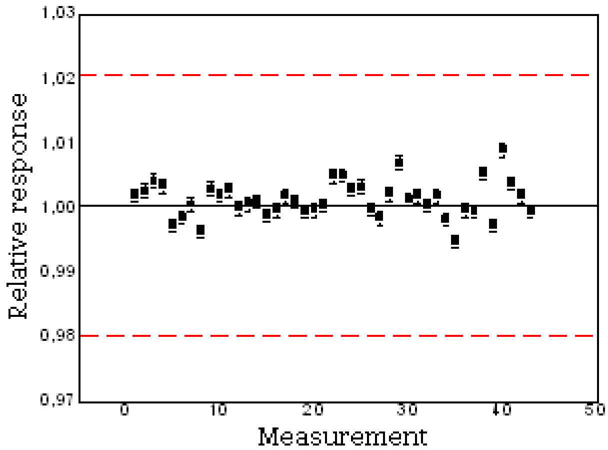
For the repeatability test, several groups of 10 consecutive measurements, under reproducible conditions, were obtained. The measurements were corrected for the normal conditions of temperature and pressure, and each group was measured in a different day. The coefficient of variation of each group of 10 measurements shall be lower than ±3% [1].

The maximum coefficients of variation for the repeatability test of the Farmer-type ionization chamber were 0.16% and 0.18%, for the check device and X-radiation, respectively. For the transmission chamber, the maximum coefficients of variation determined by the response of the repeatability test were 1.02% with the check device and 0.19% with the X-ray generator.

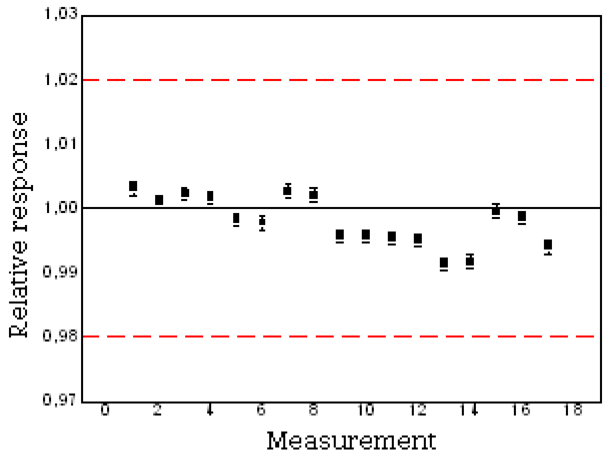
3.3. Long term stability

In the long term stability test the stability of the ionization chamber was evaluated during a time period, analyzing the results of the repeatability test. The decay of the (^{90}Sr + ^{90}Y) source must be considered in the correction of the measurements as well as the environmental conditions (temperature and pressure). According to the recommendations of the IEC 61674 [1], the variation of the response shall not be greater than ±2% over a period of one year. The mean values obtained from the repeatability tests were normalized for the mean value of the first ten results.

The maximum variations obtained were 0.89% and 0.87% using the check device and the X-ray generator, respectively, for the Farmer-type ionization chamber. These results can be observed in Figure 1.



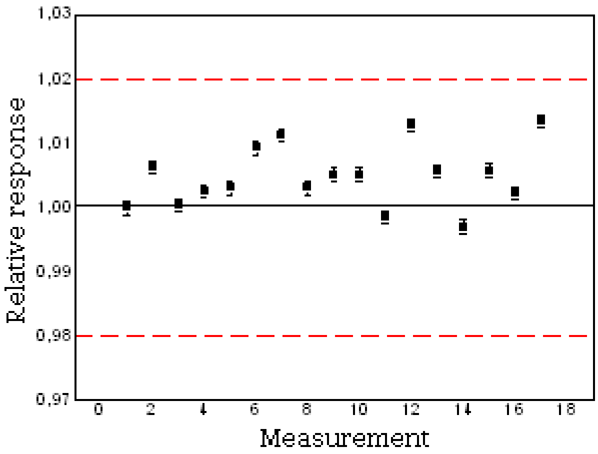
(a)



(b)

Figure 1: Long term stability of the Farmer-type ionization chamber using: a) the check device, and b) X-radiation. The hatched lines show the limits recommended by the IEC publication [1].

For the transmission ionization chamber, the maximum variations of the long term stability were 1.34% and 1.11% using the check device and X-radiation, respectively. These results can be observed in Figure 2.



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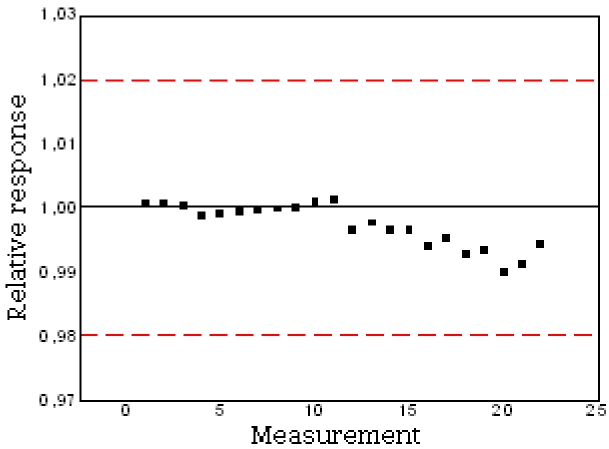

(b)

Figure 2: Long term stability of the transmission ionization chamber using: a) the check device, and b) X-radiation. The hatched lines show the limits recommended by the IEC publication [1].

4. CONCLUSIONS

Two different ionization chambers were tested following the recommendations of the International Electrotechnical Commission (IEC 61674). They showed a satisfactory performance for all evaluated quality control tests. It was observed that the tests performed using the X-ray tube showed lower deviation values than with the check device. It probably occurred in spite of the higher intensity of the X-ray beam.

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