CALIBRATION OF WELL-TYPE CHAMBERS IN BRAZIL USING ^{192}Ir HDR SOURCES

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ABSTRACT

The results obtained by performing of a traceable calibration service for well-type reentrant ionization chamber for HDR ^{192}Ir sources used in brachytherapy physical procedures at the Laboratório de Ciências Radiológicas from Universidade do Estado do Rio de Janeiro – LCR/UERJ are described.

Introduction:

The accurate determination of source strengths of ^{192}Ir High Dose Rate – HDR - sources is extremely important. The recommendation for the dose specification for brachytherapy due to physical procedures should be pursued to an uncertainty of less than 5%. This implies that the hospital ionization chambers need to be calibrated in terms of air kerma strength with an accuracy of near 3%. Up to the year of 2012 there were no traceable calibration service available and the chambers must be sent to an Accredited Dosimetry Calibration Laboratory – ADCL- or to a Secondary Standards Dosimetry Laboratories – SSDL - in United States or Europe. Now, in Brazil, the Laboratório de Ciências Radiológicas from Universidade do Estado do Rio de Janeiro – LCR/UERJ- offers calibration for well-type re-entrant ionization chamber for High Dose Rate (HDR) ^{192}Ir sources making use of a technique developed by Goetsch et al in 1991 to derive the ^{192}Ir HDR calibration factor for the 0.6 cm^3 Farmer type chamber that is maintained as the interim reference standard. In this method the value of the calibration coefficient for ^{192}Ir, N_k(Ir), for the ionization chamber used for in-air measurement is determined by an interpolation between traceable calibration factors for ^{137}Cs and 250 kVp (HVL = 3.2 mmCu) x-ray. In 1998 Marechal *et al* proposed a weighted energy interpolation method between the energies of 250 kVp and ^{60}Co, and this is the actual procedure recommended by the International Atomic Energy Agency - IAEA. A direct comparison of the calibrations results between the University of Wisconsin Accredited Dosimetry Calibration Laboratory – UWADCL - and LCR/UERJ, using same formalism to calculate the air kerma, shows an agreement better than 1.0 % for the calibration coefficients, Di Prinzio and deAlmeida in 2009.

Objectives:
Establish and perform a traceable calibration service for well-type reentrant ionization chamber for HDR ^{192}Ir sources used in brachytherapy physical procedures with an uncertainty less than 5 %.

Material and Methods:
Due the presence of higher energy photons in the ^{192}Ir spectrum it is not possible to use the free air ionization chamber (the primary standard in the kV region) as a suitable primary standard for the ^{192}Ir HDR source. Also the graphite cavity chamber (the primary standard for the ^{60}Co energy) is improper for this purpose owing its low sensitivity.
As there is no traceable to a primary standard of air kerma strength – AKS – and an indirect method is used in the absence of direct traceable calibration, the accuracy of the ^{192}Ir HDR source calibration factor of the hospital well-type chamber is difficult to estimate. The calibration technique developed by Goetsch et al in 1991 measures the source output at seven distances in air and applies an interpolation to determine the ^{192}Ir HDR source air kerma strength - AKS. The ADCLs that offer calibration for the ^{192}Ir HDR source determine the calibration factor for the 0.6 cm^3 Farmer type chamber maintained as a provisional reference standard. This gives an interim traceable calibration to hospitals and clinics for the well-type chambers.
Between calibrations it is required a periodical verification for the quality assurance and quality control of the dosimetic system. This can be done using a second calibrated well-type chamber or a system usually called check device, which contains a radioactive source with a long half-life and a thermometer for temperature corrections.

Results:
The behavior of the well-type chambers available is very reproducibility and stable.
Of the twenty calibrations performed over a year and a half, between the well-type chambers manufactured by Standard Imaging and PTW, for the first minimum and maximum values of the calibration coefficient found is 4.67 x 10^5 and 4.87 x 10^5 Gy h^{-1} A^{-1} for one meter, and the second, the minimum and maximum values of the calibration coefficient found is 9.49 x 10^5 and 9.74 x 10^5 Gy h^{-1} A^{-1} for one meter.
For quality control purposes, so far, does not have any data of the same well-type chamber of user calibrated twice, but the chamber PTW of LCR/UERJ was calibrated three times and the values were less than 1%.
An uncertainty analysis was performed and establishes for a coverage factor, k, equal to 2, an overall expanded uncertainty of ± 2.3 %.

Conclusions:
Since 2012 20 well-type chambers, models from Standard Imaging and PTW, have been calibrated at LCR. As those equipment presents a very stable behavior all the calibrations coefficients obtained at LCR stayed inside the historical calibration range found by UWADCL Calibration Service, for the same type of equipment. This shows that the knowledge and quality assurance necessary for those calibrations were acquired and the service in now available in Brazil for Guiana, Suriname and all Latin American countries.

References:
S. J. Goetsch, F. H. Attix, S. W. Pearson and B. R. Thomadsen, ‘‘Calibration of ^{192}Ir high-dose-rate afterloading systems,’’ Med. Phys. 18, 462–467 (1991).
M. H. Marechal, “A new calibration method for ^{192}Ir high dose rate brachytherapy sources,” thesis, State University of Rio de Janeiro, 1998.

R. Di Prinzio and C. E. deAlmeida, “Air kerma standard for calibration of well-type chambers in Brazil using ^{192}Ir HDR sources and its traceability,” Med. Phys. 36, 953-960 (2009).