Determination of a radiation quality correction factor for well-type ionization chambers for the determination of the dose rate of cobalt-60 brachytherapy sources

The responses of well-type ionization chambers for iridium-192 and cobalt-60 HDR brachytherapy radiation sources were determined. From their quotients, a radiation quality correction factor specific to the chamber type could be determined which allows measurement of the dose rate of cobalt-60 sources with a well-type ionization chamber calibrated for iridium-192.

Brachytherapy is a radiation therapy method which is used in oncology. In this therapy, small sealed radioactive radiation sources are placed inside the tumour or close to it in order to apply a sufficiently high dose to kill cancerous cells and to protect, at the same time, the surrounding healthy tissue as far as possible. In the case of HDR brachytherapy (HDR = High Dose Rate), radiation sources with a high dose rate (a few 10 mGy/h at a distance of 1 m) are applied which remain in the body of the patient only for a few minutes. An HDR brachytherapy source (diameter: approx. 1 mm, length: approx. 5 mm) is connected with a flexible steel wire (Figure 1), with the aid of which it is placed (conducted through a catheter) into a hollow needle positioned inside the tumour or close to it.

Fig. 1: HDR brachytherapy radiation source (dummy).

At present, mainly the radionuclide iridium-192 is used as the source material. Cobalt-60 HDR sources are, however, also being used to an ever increasing extent [1, 2]. A great advantage of Co-60 sources is the long half-life of 5.3 years. Whereas in the case of iridium-192 with a half-life of approx. 74 days, the hospital has to replace its HDR source after just a few months, a replacement is mostly only required after a few years when cobalt-60 is used. Cobalt-60 is, therefore, used, for example, to an ever increasing extent in developing countries and in countries in transition, in which the use of iridium-192 sources is not possible or is uneconomical due to the – compared to the half-life – long times required for transport and customs clearing formalities.

The prerequisite for a therapeutic success of HDR brachytherapy is a treatment plan with precise knowledge of the dose rate of the HDR sources used in the measurand "Reference Air Kerma Rate" (RAKR). For the measurement of the RAKR, the hospitals mainly use well-type ionization chambers as secondary standards. For iridium-192, their traceability is ensured by a great number of national metrology institutes, whereas only PTB offers calibrations of well-type ionization chambers for cobalt-60 in the measurand RAKR [3].
To investigate whether well-type ionization chambers which have been calibrated for iridium-192 in the measurand RAKR can also be used to determine the dose rate of cobalt-60 sources, investigations have been carried out within the scope of a research project in cooperation with the industrial partner Nucletron (Nucletron B.V., Veenendaal, Netherlands). For this purpose, the response of well-type ionization chambers was determined for both iridium-192 and cobalt-60 HDR brachytherapy sources. The investigations were aimed at determining a radiation quality correction factor $k_Q$ which is specific to the chamber type and allows the RAKR of cobalt-60 brachytherapy sources to be determined with well-type ionization chambers which have been calibrated for iridium-192. For this purpose, seven identical well-type ionization chambers of the type TM33004 of the company PTW were investigated (Figure 2).

![Well-type ionization chambers, type PTW TM33004.](image)

The response of the well-type ionization chambers was determined with the aid of an iridium-192 and a cobalt-60 brachytherapy source which had previously been characterized [4] and whose RAKR was determined with the calibration facility of PTB [5]. To place the calibrated radiation sources into the well-type ionization chamber to be investigated, a remote-controlled afterloading system (a so-called afterloader) was used which had been developed for PTB (Figure 3).

![Well-type ionization chamber with afterloader for remote-controlled positioning of a HDR brachytherapy source via a catheter.](image)
Within the scope of the measurement uncertainty of 0.3 %, the ratio of the response for iridium-192 to the response for cobalt-60 was identical for all seven well-type ionization chambers investigated. This shows that well-type ionization chambers with chamber-type-specific radiation quality correction factors can be used for dosimetry in brachytherapy. In future it will, therefore, be possible to determine the RAKR of cobalt-60 brachytherapy sources with a well-type ionization chamber of type TM33004 which has been calibrated with iridium-192. A paper with a detailed description of the experiments and of the analyses of the chamber-to-chamber variation of a total of 33 well-type chamber specimens for this and for another well-type chamber type, of the influence of the source-to-source variation of iridium-192 and cobalt-60 sources, and of the dependence on the source activity has been submitted for publication.

Literature:
[3] Research News from Division 6 (2005) Calibration of well-type ionization chambers for 192Ir and 60Co brachytherapy sources in units of the characteristic dose rate

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