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PROGRESS REPORT ON RADIATION DOSIMETRY STANDARDS, FACILITIES AND RELATED TOPICS at NMi, 2001-2002

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1. Introduction

The following sections present brief summaries on activities related to standards, facilities and calibration services at NMi Van Swinden Laboratory over the period 2001-2002 with respect to radiation dosimetry. Research activities have been focussed in this period on water calorimetry [1,2] and the development of a primary standard for beta sources used in medical applications [5]. Cooperation with the Netherlands Commission on Radiation Dosimetry (NCS) and with the Belgian and Dutch Societies for Clinical Physicists has been intensified. NMi is active in several NCS working parties dealing with topics in the field of dosimetry and quality assurance in radiotherapy and diagnostic radiology. In separate contributions to the CCRI the present status of the portable NMi water calorimeter and the primary standard for medical beta sources is described.

2. Reference dosimetry for high-energy photon and electron beams

The NCS Subcommittee “Uniformity Dosimetry Protocols” is currently drafting new codes of practice for absorbed dose determination in high-energy photon and electron beams used in radiotherapy institutes in Belgium and The Netherlands [3]. The new codes of practice will replace the current codes of practice described in NCS reports 2 and 5, which are based on air kerma standards. The new codes will be based on an absorbed dose to water standard in a ^{60}Co reference beam and on the concept of a beam quality correction factor k_Q. . Current activities of the subcommittee concentrate on the dosimetry for photon beams. The subcommittee intends to tabulate measured k_Q factors for high-energy photon beams for four types of (reference) ionisation chambers commonly used in radiotherapy institutes in Belgium and The Netherlands. These k_Q factors will be generic, based on the comparison of the dosimetry results of six ionization chambers of each type with water calorimetry measurements. The k_Q factors will be measured at 9 selected institutes, covering representative clinical radiation beam qualities and types of medical accelerators, using the portable NMi water calorimeter. With respect to k_Q factors for high-energy electron beams the subcommittee has decided to tabulate calculated values.
In 2002 preliminary measurements were performed with the NMI water calorimeter

and NE2611A ionisation chambers in high-energy photon beams in a few selected hospitals and in the French Primary Standards Laboratory (BNM-LNHB) [4]. After calibration of all selected graphite walled ionisation chambers (24 in total) in the NMi ^{60}Co gamma ray beam, the measurements in the clinical photon beams will start in the spring of 2003. Both beam quality specifiers $dd(10)_x$ and $TPR_{20,10}$ will be determined for all selected photon beams.

3. Re-evaluation of wall and non-uniformity correction factors

Work is in progress to re-evaluate the correction factors for attenuation and scatter in the walls of the existing NMi primary standard cavity ionisation chambers. The primary air-kerma standards for ^{60}Co comprise a 5 cm^3 spherical and a 2.5 cm^3 cylindrical graphite walled ionisation chamber. Also the correction factor for axial non uniformity will be calculated for both chambers. The correction factors will be determined using the Monte Carlo code PENELOPE. The project has been delayed in 2002 by lack of staff, but the project was resumed in March 2003.

4. Calibration of ^{192}Ir brachytherapy HDR sources

NMi operates a calibration service for HDR ^{192}Ir sources used in brachytherapy. The calibration coefficient is determined by weighting the energy response of the ionisation chamber over the photon energy spectral distribution of the ^{192}Ir source. Some national metrology institutes employ a similar method, while others use a different method, e.g. the method described in IAEA TECDOC 1274. In order to investigate the different methods in use by standards laboratories, an intercomparison exercise was initiated by the IAEA together with PTB, University of Wisconsin and NMi. The intercomparison started at the end of 2002 with the calibration of four different ionisation chambers (NE 2571, PTW 30010, Exradin A12 and Exradin A3) at NMi. The measurements at NMi were completed at the end of January 2003 and the chambers have been sent to PTB. The measurements are expected to be completed in 2003 and the results of the comparison will be published.

5. Comparisons

An indirect comparison was carried out in November 2002 for the quantity air kerma for medium energy X rays between NMi and BIPM with three transfer ionisation chambers (NE2611A and NE 2571).The measurements involved the four CCRI reference beam qualities in the range of 100 – 250 kV. Results are still preliminary, but are very satisfactory for all beam qualities and are within 1-2 ‰ compared to the results of the previous comparison conducted in 1991.

NMi has been involved in a Euromet comparison concerning the calibration of dosemeters used in mammography (Euromet project 526). This intercomparison project is coordinated by BEV.

NMi participated in the international comparison of the dissemination of primary standards of absorbed dose to water for ^{60}Co gamma rays, as agreed on the CCRI(I) meeting in 1999: CCRI(1)-K4. In July 2001 NMi has calibrated three transfer ionisation chambers (NE2611A, NE2571 and ND1006) in terms of absorbed to dose to water in a ^{60}Co beam. The key comparison is co-oordinated by the BIPM. No results have been published yet.

6. Beta-ray standards

Work is in progress to develop a new primary standard for measuring the absorbed dose to water and dose rate distribution of beta particle emitting sources used in medical applications (e.g. the use of ophthalmic applicators and sources employed in intravascular brachytherapy). The design of the primary standard is based on the principle of a parallel plate ionisation chamber. In a separate working paper to the CCRI(I) the progress of this project will be described. In co-operation with the Catharina Hospital Eindhoven and the Technical University Eindhoven a project has been undertaken to develop dosimetry methods for clinical use and to develop transfer methods for absorbed dose (rate) calibrations based on the extrapolation chamber of NMi. A working party of the NCS was established to investigate current practice on QC methods for beta sources used in Dutch and Belgian hospitals and to give recommendations on suitable measurement methods.

7. Dosimetry and quality assurance in brachytherapy

A task group of the NCS in cooperation with NMi has published guidelines for quality assurance (QA) in brachytherapy. The main goal of this work is to gain insight into current practice of QC in brachytherapy in all radiotherapy institutions in The Netherlands and Belgium and to reduce possible variations in test frequencies and variations by formulating a set of minimum QC-requirements. The work was reported at the last CCRI(I) meeting in 2001. The guidelines were published as NCS report 13 (November 2000). Parts of the study have been published in the literature [7,8].

8. Automation measurement facilities

New computer software for data acquisition and instrument control of the X-ray calibration facilities has been developed based on the object oriented computer language Delphi. An important feature is the use of a database structure and the possibility to share program modules for instrument control and read out of measurement equipment. Presently the software is being installed on the measurement facilities for ^{60}Co gamma rays. In the future the software program will also include applications for automated generation of certificates, which is under development at NMi.

9. ISO/IEC 17025 accreditation

According to the CIPM mutual recognition arrangement (MRA), one of the requirements to ensure mutual recognition of equivalence of national standards and calibration certificates is the implementation of an operational quality system by national metrology institutes. NMi decided to be accredited according to ISO/IEC 17025 by the Dutch Council for Accreditation (RvA). All calibration services of the ionising radiation section have been successfully accredited in 2001.

10. Publications

[1] M.W.H. Pieksma, E. van Dijk and A.H.L. Aalbers, The NMi absorbed-dose-to-water calorimeter (a status report), Proc. of the Int. Workshop on Recent Advances in Calorimetric Absorbed Dose Standards NPL Report CIRM 42: 85-89 (2000)

[2] M.W.H. Pieksma, L.A. de Prez and A.H.L. Aalbers, The NMi water calorimeter, Proceedings of the International Workshop on Recent Developments in Accurate Radiation Dosimetry (McGill University, Montreal), AAPM Proceedings Series 13, Medical Physics Publishing, Madison, Wisconsin, pp. 108-119 (2002)

[3] A.H.L. Aalbers et al., Clinical Reference Dosimetry for High-Energy Photon and Electron Beams: Revision of the NCS Codes of Practice, Klinische Fysica 2002 vol. 2+3, pp. 6-9

[4] M.W.H. Pieksma, L.A. de Prez, E. van Dijk, A.H.L. Aalbers, Measurements of k_Q beam quality correction factors for the NE2611A chamber in high-energy photon beams using the NMi water calorimeter IAEA-CN-96-7 (2002)

[5] J. van der Marel and E. van Dijk, Development of a Dutch primary standard for beta-emitting brachytherapy sources IAEA-CN-96-71 (2002)

[6] E. van Dijk, Comparison of two different methods to determine the air kerma calibration factor (N_k) for ^{192}Ir IAEA-CN-96-75 (2002)

[7] R.J.M. Elfrink et al., Determination of the accuracy of implant reconstruction and dose delivery in brachytherapy in The Netherlands and Belgium, Radiotherapy and Oncology 59 (2001), 297- 306

[8] R.J.M. Elfrink et al., Quality control of brachytherapy equipment in the Netherlands and Belgium: current practice and minimum requirements, Radiotherapy and Oncology 62 (2002), 95-102