

CCRI(I)

Progress report on radiation dosimetry standards, facilities and related topics at VSL, 2009 – 2011

J.A. de Pooter
VSL
The Netherlands

1. Introduction

The following sections present brief summaries on activities related to standards, facilities and calibration services at VSL Van Swinden laboratory over the period 2009 –2011 with respect to radiation Dosimetry. Research activities at VSL have been focused on absorbed dose to water for HDR Ir-192 brachytherapy sources, low energy photon dosimetry, 3D-dosimetry in complex and very small radiotherapy beams, used in IMRT and radio surgery and a start has been made for proton dosimetry.

2. Accommodation and facilities

In 2009 an afterloading system was installed in the framework of the development of a water calorimeter for HDR Ir-192 sources.

3. Air kerma standard and facilities**3.1 Re-evaluation of correction factors for the Free-Air Chamber ($E = 50 \text{ keV}$ to 320 keV)**

In 2010 a project was started for re-evaluation of the Monte-Carlo calculated correction factors for the medium energy X-rays free-air chamber. The correction factors will be calculated with the Penelope code. Contrary to the original calculations the electrical field will be included in the simulations. The project will finish at the end of 2011.

3. Absorbed Dose standards**3.1 Absorbed dose standard for low-energy photon**

In the last years the use of low energy photon sources became more relevant in radiotherapy. An example is the use of ^{125}I seeds in case of prostate cancer. At VSL a project has been started in 2007 to investigate the possibility of determining the absorbed dose to water for low energy, low dose rate sources. Some source and phantom geometries have been simulated with MC code PENELOPE, to investigate the interface effects that occur at the phantom-detector interface crossing of photons en electrons. In 2009 a standard has been designed and constructed. The first measurements have been performed in 2010. Due to problems with stabilisation of the measurements signal the project was stopped.

3.2 3D-dosimetry

Developments in radiotherapy are progressing fast. Treatment techniques such as Intensity Modulated Radiation Therapy (IMRT), TomoTherapy and radiosurgery considerably improve the treatment of cancer patients. Because of the increase in complexity of the dose delivery for these techniques, absolute dosimetry in a single point is more difficult and additional knowledge of the dose distribution in a 3D volume is necessary. Based on radiochromic film dosimetry a 3D dosimetry

is being developed. In 2008 the readout system for the radiochromic film, a flatbed scanner, was characterized with respect to polarization, position dependent variation in scanner sensitivity. Also the dose response curve was determined and a correction method for position dependent variation in film sensitivity was developed which decreased the uncertainty contribution due this variation with 50%. The method of film dosimetry was validated for homogeneous fields. End of 2008 a simple (i.e. homogeneous) anthropomorphic phantom was designed and constructed.

In 2009, the first measurements for inhomogeneous fields were performed. The measurements were validated with Monte Carlo simulations. In 2010 measurements for complex radiation fields in Linac beams have been performed.

3.3 Absorbed dose standard for HDR sources

Within the framework of EMRP – JRPo6 a water calorimeter for HDR sources is being developed. The source self-heat was modelled and determined. A method to reduce the source self-heat was developed. The design for the new high purity cell was made. And the HPC has been constructed and assembled in 2009. The first measurements have been performed in May 2010, and simulations for correction factors have been determined. Some improvements have been made in the beginning of 2011. Final realisation of the standard is expected for the end of 2011.

3.4 Proton dosimetry

In 2010 a project proposal was accepted for the development of a water calorimeter as primary standard for proton dosimetry. In this project VSL cooperates with the University Medical Centre Groningen and the KVI (Groningen). The project will start half 2011.

4. Key comparisons

In November 2009 VSL has participated in the running BIPM.RI(I)-K8 comparison on RAKR for HDR ^{192}Ir sources. The results of this comparison are still under evaluation. Participation for mammography and low-energy X-ray (BIPM.RI(I)-K3) comparisons is planned for Jan. 2012.

5. Auditing

Since 2008 VSL participates in a working group of the Netherlands commission on Radiation dosimetry (NCS) for the auditing of Dutch and Belgium radiotherapy departments. During the on-site visits the reference dosimetry for the determination of the absorbed dose to water in high energy photon beams (6 MeV to 23 MeV) according the NCS 18 Code of Practice, is audited. The VSL serves as piloting institute in this audit. In 2010 the measurements have been finished. Preliminary results have been presented at the IDOS symposium in Vienna Nov. 2010. Final results are underway.

6. Dosimetry and quality assurance of low-energy photon sources in brachytherapy

Since 2004 VSL cooperates with a working party of the Netherlands Commission on Radiation Dosimetry, which investigates the clinical practice of QA aspects related to the use of low energy photon (LEP) sources in Belgium and the Netherlands. The final aim of the working party is to publish recommendations for QC regarding the use of LEP sources in brachytherapy applications and to foster the development of a calibration facility for those sources in Belgium and the Netherlands. Part of the study was the verification of the source strength of LEP sources on location by a visiting team. Air kerma strength measurements were performed for all types of LEP sources currently in use in Belgium and the Netherlands using two commercially available measurement systems. Except for one source type both measurement systems were calibrated at VSL using NIST traceable sources of the types employed in Belgian and Dutch radiotherapy centres. The results measured by the visiting team were compared to measurements performed by the local medical physicist and to the source strength specified on the manufacturer's certificate. Results concerning the "on-site" visits have been presented on the IDOS symposium in Vienna in Nov. 2010.

7. Publications (May 2009 – May 2011)

D.T. Burns and L.A. de Prez, “Key comparison BIPM.RI(I)-K3 of the air-kerma standards of the VSL, Netherlands and the BIPM in medium-energy x-rays”, Metrologia 46 No 1A (Technical Supplement 2009)

C. Kessler, P.J. Allisy-Roberts, D.T. Burns, P. Roger, L.A. de Prez, J.A. de Pooter and P.M.G. Damen, “Comparison of the standards for absorbed dose to water of the VSL and the BIPM for ^{60}Co γ -rays”, Metrologia 46 No 1A (Technical Supplement 2009)

J.A. de Pooter, L. de Prez, W. de Vries E.van Dijk, “Effective reduction of uncertainty for water calorimetry of HDR sources”, ESTRO annual meeting 2009, Maastricht.

Maria Pia Toni, Isabelle Aubineau- Lanière, Maurizio Bovi, Jean-Marc Bordy, João Cardoso, Bruno Chauvenet, Frantisek Gabris, Jan-Erik Grindborg, Antonio Stefano Guerra, Antti Kosunen, Carlos Oliveira, Maria Pimpinella, Thorsten Sander, Hans-Joachim Selbach, Vladimír Sochor, Jaroslav Šolc, Jacco de Pooter, Eduard van Dijk, “Traceability to absorbed-dose-to-water primary standards in dosimetry of brachytherapy sources used for radiotherapy”, XIX IMEKO World Congress Fundamental and Applied Metrology, 2009, Lisbon, Portugal

M.P. Toni, I. Aubineau-Lanière, M. Bovi, J. Cardoso, D. Cutarella, F. Gabris, J.E. Grindborg, A.S. Guerra, H. Jarvinen, C. Oliveira, M. Pimpinella, J. Plagnard, T. Sander, H.J. Selbach, V. Sochor, J. Solc, J. de Pooter and E. van Dijk, “A Joint Research Project to improve the accuracy in dosimetry of brachytherapy treatments, in the framework of the European Metrology Research Programme,” World Congress on medical physics and biomedical engineering, Munich, 2009

J.A. de Pooter, L.A. de Prez, *Development of a water calorimeter as a primary standard for absorbed dose to water measurements for HDR brachytherapy sources, International symposium on dosimetry and standards (IODS), Vienna, 2010.*