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Recent Activities in Measurement Standards and Dosimetry at ARPANSA, 2001-2003

David V Webb, Robert B Huntley, Lew H Kotler, Duncan Butler and Milly J Cox

Ionizing Radiation Standards Section, Medical Radiation Branch

Australian Radiation Protection & Nuclear Safety Agency (Melbourne)
619 Lower Plenty Road, Yallambie, Victoria 3085, Australia
Telephone: +61 3 9433 2211, Facsimile: +61 3 9432 1835
E-mail: arpansa@health.gov.au, Website: http://www.arpansa.gov.au

1. INTRODUCTION

The Ionising Radiation Standards Section continues to maintain Australian standards of air kerma and absorbed dose and to provide calibration services for therapy, diagnostic and protection equipment. No staff changes have occurred since the previous meeting of the CCRI(I) in 2001, but directions of interest have been affected by the need to support the regulatory functions of ARPANSA. More emphasis has been placed on the security of sources and the implementation of a quality system.

2 EXPOSURE /AIR KERMA STANDARDS

2.1 Kilovoltage X-rays

2.1.1 Low energy X-rays (10-50 kV)

The RT100 x-ray unit had been aligned previously and is in routine use for calibration of client equipment. The AEG50 unit has now been aligned and was used in the BIPM comparisons in June 2002.

The intercomparison with BIPM at low energies (see Section 2.3.1) indicated that the use of the smaller free air chamber for the Australian low energy primary standard was not justified. The results suggested that its collecting volume could not be determined accurately from only geometrical considerations. The BIPM has provided calibration coefficients for the two transfer chambers that were used in the intercomparison. The response of these transfer chambers with the response of the medium energy standard chamber in the range 50 kV to 100 kV, will allow the chamber formerly used as the low energy primary standard, to be used as a secondary standard for routine use in the calibration of client equipment.

2.1.2 Medium energy X-rays (50-300 kV)

New correction factors provided by D Burns, based on theoretical X-ray spectra and Monte-Carlo calculations, have been introduced for the medium energy free air chamber. These are appropriate to therapy, diagnostic and ISO protection level beams used in calibrations that we offer to our clients.

In addition, we are developing a method of rationalising the measured calibration coefficients for each type of frequently used ionisation chamber in order to significantly lower from twenty-five the number of beam qualities we offer clients. This is to be achieved by generating, in advance, a generic analytic curve shape that relates the chamber calibration coefficient to the half value layer of the beam over the available range of half-value layers. The calibration then consists of a minimal number of chamber measurements that normalise the curve parameters to the response of the specific chamber. These curve parameters were presented to hospital physicists at the annual meeting of the ACPSEM in November 2001.

2.1.3 Provision of absorbed dose calibrations at X-ray qualities

Discussion has commenced with the Australian medical physics community concerning provision of absorbed dose calibrations for medium and low energy X-ray qualities. As ARPANSA at this stage will not be providing direct absorbed dose calibrations at these x-ray qualities, the discussions will concern provision of tabulated correction factors, based on published information from both the AAPM TG-61 protocol and the revised IPEMB code of practice.

2.1.4 Determination of beam uniformities

We are digitizing films that have been exposed to X-ray beams with a view to using software to determine cross-sectional beam uniformity. We have found that many conventional flat bed scanners do not deliver a sufficient dynamic range to allow use of the scanned image. Work is proceeding using more sophisticated scanners that allow operator control of the scanning process to improve the dynamic range of the scanned image.

2.1.5 X-ray spectra characterisation

Following the earlier measurements of spectra from the X-ray tubes used for the ARPANSA primary standards several comparisons have been made between spectra calculated by two analytical models and EGSnrc. The models were found to give slightly different results, but no conclusions were drawn about the superiority of any model. All models gave results that were qualitatively similar to the measured spectra.

2.2 Gamma-rays from ^{60}Co and ^{137}Cs

2.2.1 A report on the comparison between ARPANSA and NRC in 1997 of air kerma and absorbed dose to water standards for ^{60}Co is close to completion. As shown by the ratio of the transfer standard ionisation chamber calibration coefficients, the standards are in agreement to within 0.5%. A formalisation of the common practice of utilising comparisons with a third standards laboratory as a cross check on bilateral comparison results has been developed. This process is referred to as a trilateral comparison and shows that the uncertainty associated with the bilateral comparison results is considerably less than is usually reported.

2.2.3 A report on the carbon cavity chamber that is the primary standard in the ^{60}Co beam is almost ready for publication.

2.2.4 A report on a recent comparison of air kerma and absorbed dose to water standards with METAS at ^{60}Co is in preparation.

2.2.5 The ^{60}Co and ^{137}Cs teletherapy sources have been realigned to produce parallel beams (previously the beams intersected). Rails have been installed to facilitate measurements at different distances. Shock absorbers have been installed on the source drawers, to prevent damage to the end stops during source transit. A video capture system has been developed to measure the source transit velocity profile. A three dimensional micrometer stage is being installed to improve the accuracy of thimble chamber positioning in the water phantom.

2.3 International intercomparison activity

2.3.1 Key comparisons

A. APMP.RI(I)-K3: The APMP medium energy intercomparison, which has been coordinated by INER (Taiwan), started in July 2000 and is expected to be completed in June this year. Eleven laboratories have participated. ARPANSA completed its measurements in November 2001.

B. BIPM.RI(I)-K3: Lew Kotler visited the BIPM in June 2002 with three medium energy transfer chambers and two low energy transfer chambers for comparisons at all BIPM medium and low energy standard X-ray qualities. As indicated in Section 2.1.1, participation in BIPM.RI(I)-K2 cannot be proceeded with until such time that a low energy standard is re-established.

C. APMP.RI(I)-K1: The comparison of air kerma standards at ^{60}Co is being coordinated by KRISS (Korea) with assistance from ARPANSA. A protocol has been developed and and has been accepted by the APMP-TCRI but needs to be ratified by BIPM-CCRI before measurements begin. Three NE2571 chambers (two from ARPANSA and one from INER) will be calibrated by the two pilot laboratories, ARPANSA and BARC who also provide links to the BIPM, before and after circulation amongst the participants.

2.3.2 Bilateral intercomparisons

A. A bilateral comparison with the NRCC was completed in 1997-1998 for the medium energy X-ray BIPM standard qualities, the 50 kV low energy standard qualities and for ^{60}Co. The report has not yet been finalised.

B. In 1999, we performed a bilateral comparison with the INER (Taiwan) for the medium energy X-ray BIPM standard qualities but this has not been written up as yet.

C. In late 2002 and into 2003, a comparison was performed with NRL (New Zealand) for BIPM medium energy qualities, BIPM low energy qualities at 30 and 50 kV and for three ISO protection level qualities in the range 30 to 200 kV, plus ^{137}Cs at protection levels.

D. Following the visit to the BIPM in June 2002, a comparison was made at the NPL (UK) for four IEC diagnostic level qualities in the range 40 to 90 kV, four ISO protection level qualities in the range 60 to 300 kV, plus ^{241}Am at protection levels. The final measurements at ARPANSA were completed earlier this year.

3 ABSORBED DOSE STANDARDS

3.1 The Australian primary standard for photons

Two thermistor failures in the first jacket of the ARCS graphite calorimeter that is used to maintain the Australian primary standard for absorbed dose, has made the device inoperable. Repairs will be attempted this year. A similar calorimeter is on loan from the IAEA, for use as a temporary standard while repairs are effected. The IAEA calorimeter was manufactured in an earlier batch by ARCS in the 1980s, but has not previously seen active use. There have been some minor problems with the control system electronics and these are under investigation.

3.2 A primary standard for electrons

This project is awaiting the allocation of staff. It may be advanced as a postgraduate student project. A graphite electron calorimeter has been purchased from the NPL.

3.3 Mega-voltage X-ray and electron beams

The linear accelerator is used primarily to support absorbed dose{ XE "dose" } standards at therapy energies. During most of 2001, the dosimetry{ XE "dosimetry" } X-ray{ XE "X-rays" } beam line was unavailable while beam-defining slits were repaired and reinstalled. X-ray beams were re-established in April 2002 and the development of standard beams from 8 to 20 MV has re-commenced. We are participating in EUROMET Project 605 investigating the beam quality specification of high-energy photon beams and should be ready to undertake the program of beam characterisation later this year.

High dose{ XE "dose" } irradiations were performed for several organisations, including the irradiation of diamond chips used in therapy radiation detectors being studied by the Australian National University{ XE "Australian National University" }. The linear accelerator{ XE "linear accelerator" } maintains a pulse radiolysis facility on behalf of the Australian Institute of Nuclear Science and Engineering and is used by several universities throughout Australia{ XE "Australian Institute of Nuclear Science and Engineering" }.

4 QUALITY SYSTEMS

4.1 Our source-based protection level calibration services (^{137}Cs, ^{60}Co and ^{241}Am) are being submitted for accreditation from the Australian National Association of Testing Authorities (NATA). Accreditation will be sought progressively over the next year for our X-ray based protection level services and diagnostic and radiotherapy level services.

4.2 NSC Verifying Authority status

Our primary standards of exposure and absorbed dose have been recently assessed by the Australian National Standards Commission (NSC) towards the granting to

ARPANSA of an interim Verifying Authority status. In Australia, this legally entitles ARPANSA to issue certificates needed by secondary standard holders to enable them to calibrate their clients' equipment and to issue legally valid calibration certificates to those clients, under the Australian National Measurement Act. Renewal of this Verifying Authority status will be conditional on achieving NATA accreditation for our calibration services.

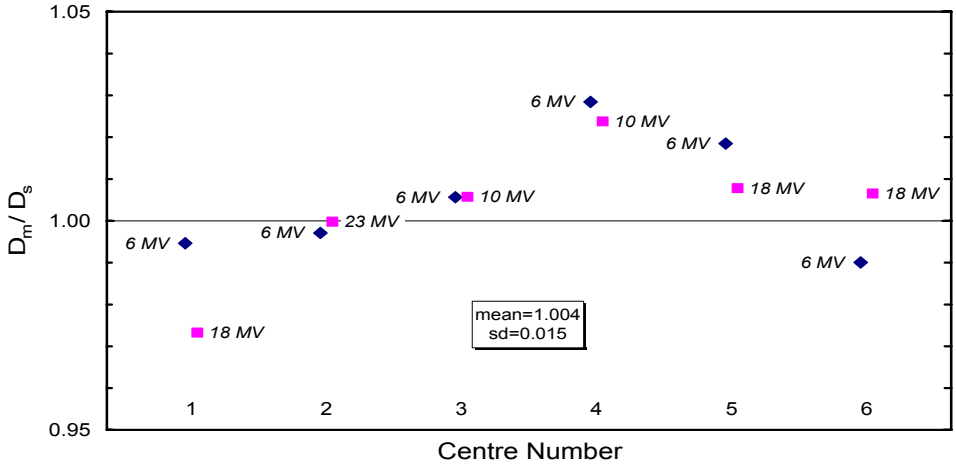
5 APPLICATIONS OF DOSIMETRY STANDARDS

5.1 IAEA PSDL and SSDL activities

We will be providing standard exposures for the third IAEA/RCA intercomparison for individual monitoring for occupational exposures. The next round will be in July this year.

ARPANSA is now a reference laboratory for the IAEA TLD QA service for radiotherapy dosimetry, and has provided annual reference irradiations of control capsules for the last two years. This activity will continue.

In addition, ARPANSA is implementing the first full round of a national TLD radiotherapy QA service. A pilot study over 6 centres was completed in August last year and good results were obtained for the dose at 5 cm depth in water (Figure 1). Australian radiotherapy centres are participating in batches of 5 or 6 centres, and the results are being evaluated using a manual TLD reader. An automatic reader is being



sought to improve the throughput and precision of the results.

Fig.1. TLD pilot study results. Ratio of measured (D_m) to stated dose (D_s)

5.2 ESR alanine dosimetry for high dose irradiations

A Bruker Model 200D-SRC ESR spectrometer was brought back into service in August 2000. A LabVIEW interface was developed to replace the analogue graphical display that facilitates the measurement of absorbed dose in l-alanine at therapy levels and higher doses up to 100 kGy. A failure in the signal acquisition system, which has been difficult to repair, has meant that the facility has been unavailable for the past year.