

Dosimetry comparisons and calibrations by the BIPM 2009 to 2011

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1. Introduction

Comparisons and calibrations at the BIPM are made in terms of the quantities air kerma, absorbed dose to water, and ambient dose equivalent, in which thirty-two NMIs and the IAEA participate periodically. The radiations used are low-energy x-ray, including the recently introduced mammography beams (10 kV to 50 kV), medium-energy (100 kV to 250 kV) x-ray beams, a 0.7 TBq ^{137}Cs source and two ^{60}Co sources (namely, CIS-Bio and NBS, currently about 65 TBq and 0.1 TBq, respectively), the smaller activity source being used for ambient dose equivalent. The results of the comparisons are published, usually as a *Metrologia Technical Supplement*. Comparisons reported at the last meeting are summarized in [1]; comparison reports that have been published since are cited here in full [2 to 28] while for those comparisons awaiting publication, draft reports are cited [29 to 38].

Twenty-one comparisons (nineteen in terms of air kerma and two in terms of absorbed dose) and forty calibrations of national standards have been carried out at the BIPM since the last meeting of Section I of the CCRI in 2009 (Table 1).

Collaboration has continued with the IAEA for the periodic TLD irradiations at the ^{60}Co radiation quality to support the IAEA/WHO dosimetry audit programme.

This period also saw the introduction of the high-energy x-ray comparisons that are now being conducted at the NMIs with accelerators. Three such comparisons have been held to date, one of which has been published [39] and the other two are in preparation [40, 41].

The BIPM prepared the report for the CCRI(I)-S2 ^{60}Co high dose comparison that was held in 2009 and is now published [42].

2. Comparisons of air kerma standards for ^{60}Co

Three comparisons of air kerma standards using the CIS Bio ^{60}Co source have been carried out since the 2009 CCRI(I) meeting. These have been made with the VNIIM (Russian Federation), the KRISS (Korea) and the ARPANSA (Australia) [19, 27, 31]; comparisons with the NIST (USA) are scheduled for 2011, including using the NBS radiation protection level source.

As usual, several experiments were undertaken at the same time as the comparisons to assess, variously, the recombination effect, the stem effect, orientation and polarity effects.

A major effort in publishing reports has been successful with eight comparison reports published and the three remaining reports close to publication [29 to 31].

In principle, there are three NMIs whose ⁶⁰Co air kerma results need to be updated as they are now over 10 years old. These are the DMDM (Serbia), NMIJ (Japan) and the NIM (China)

Table 1 Comparisons and calibrations at the BIPM from May 2009 to April 2011

Year	Country	X-rays		¹³⁷ Cs		⁶⁰ Co		
		Air kerma 10 to 50 kV ^a	Air kerma 100 to 250 kV	Air kerma	Ambient dose equivalent	Air kerma	Absorbed dose to water	Ambient dose equivalent
2009	Russia			VNIIM(1)		VNIIM(1)		
	Japan	NMIJ(3) K7					NMIJ(2)	
	France	LNHB(1)						
2010	South Africa	NMISA(2)	NMISA(2)		NMISA(1)	NMISA(2)	NMISA(2)	NMISA(1)
	Finland	STUK(1)	STUK(1)			STUK(1)	STUK(1)	
	China	NIM(2)					NIM(3)	
		IAEA(2)	IAEA(2)			IAEA(2)	IAEA(2)	
	Spain					CIEMAT(2)	CIEMAT(2)	
	Poland	GUM(1)	GUM(1)					
	USA	NIST(2)^a						
	Australia		ARPANSA(3)			ARPANSA(2)	ARPANSA(2)	
	Korea			KRISS(1)		KRISS(1)		
	Hungary		MKEH(2)					
Russia		VNIIM(1)						
Germany	PTB(2) K7							
2011	Switzerland					METAS(2)		
	Portugal	ITN(1)				ITN(1)	ITN(1)	
	Greece	HIRCL(1)	HIRCL(1)			HIRCL(1)	HIRCL(1)	
	Italy	ENEA(2)^a	ENEA(1)	ENEA(1)				

Measurements planned for 2011

2011	Argentina				IAEA(3) CRRD(1)			IAEA(3) CRRD(1)
	Hungary	MKEH						
	USA			NIST		NIST		
	Russia	VNIIM						

^a including mammography – K7

CALIBRATIONS (number of chambers)

COMPARISONS (number of chambers)

3. Comparisons of air kerma standards for ^{137}Cs

Since the last CCRI(I) meeting, three comparisons of air kerma standards, for the VNIIM, KRISS and the ENEA (Italy) have been carried out using the ^{137}Cs source at the BIPM and seven comparison reports have been published; the remaining two reports are in hand [29, 30]. The summary report to include all these results in the KCDB is ready for approval by the CCRI(I) [32].

The NIST and the NMIJ have scheduled new comparisons to update their 1994 and 2001 results respectively and, in principle the PTB (Germany) needs to schedule a new comparison to update their 2000 result.

4. Comparisons of air kerma standards for low-energy x-rays

Eight low-energy x-ray comparisons of air kerma standards have been made since the last CCRI(I) meeting, with the NMIJ (mammography), LNE-LNHB (France), NIST (including mammography), GUM (Poland), the ENEA (including mammography) and the PTB (mammography). Five reports have been published and two are close to publication [33, 34]. Comparisons with the VNIIM and the MKEH (Hungary) are scheduled for later in 2011 and with the VSL (Netherlands) for early 2012.

Three NMIs will need to schedule new comparisons before the end of 2012 as they are all over 10 years old. They are the METAS (Switzerland), PTB and the BEV (Austria).

5. Comparisons of air kerma standards for medium-energy x-rays

Five comparisons of medium-energy x-ray air kerma standards with the GUM, ARPANSA, MKEH, VNIIM and the ENEA have been made since the last CCRI(I) meeting.

The report for the VNIIM comparison has been published and draft reports for the MKEH and the ARPANSA have been issued for comment [35, 36]. The study of the NIS (Egypt) medium-energy free-air chamber was also published [7].

Five NMIs will need to schedule new comparisons before the end of 2012 in order to comply with the recommendation of the CCRI(I) as they are all over 10 years old. They are the MKEH, NRC (Canada), PTB, NIM and the BEV.

6. Comparisons of absorbed dose standards

For ^{60}Co

Two new comparisons of the absorbed dose standards in terms of absorbed dose to water for ^{60}Co have been made with the NMIJ and the ARPANSA. The comparisons

were both made using ionization chambers as transfer instruments and the NMIJ comparison report has been published [18].

Five other comparison reports have been published and the remaining two [37, 38] are still to be finalized and then these results will be added to the KCDB.

Both the METAS and the MKEH need to schedule comparisons in accordance with the CCRI(I) recommendation.

A comparison of absorbed dose to graphite was made with the LNE-LNHB to check the validity of graphite calorimetry measurements and conversion factors.

For accelerator x-ray beams

Three NMIs have now participated in the BIPM.RI(I)-K6 accelerator dosimetry comparison: the NRC, PTB and the NIST. The report for the NRC participation has been published [39] and the other two are at an advanced stage [40, 41].

Three further comparisons are scheduled for 2011 and 2012, for the NPL, LNE-LNHB and the ARPANSA. The outcome of the CGPM in October 2011 is awaited to see what else can be scheduled in the next 4-year programme.

7. Calibrations in terms of air kerma, absorbed dose to water and ambient dose equivalent

Dosimetry calibrations have been made for South Africa, Finland, China, Spain, Switzerland, Portugal, Greece and the IAEA. Seventeen of the forty national standards (Table 1) that were submitted for calibration to the BIPM were re-calibrations. In general, the values are consistent with the statistical uncertainty of a calibration (0.07 %).

There has been one external audit and one internal audit of the BIPM Quality System (QS) for dosimetry calibrations since the last CCRI(I) meeting. The auditors declared satisfaction with the QS and no significant non-conformities were identified. Several minor improvements have been implemented in accordance with the reviewers' suggestions. The BIPM is grateful to its NMI colleagues who serve as peer reviewers for this purpose. The next external audit is scheduled to take place in 2012.

8. Conclusion

The recommendation made by the CCRI(I) under the CIPM MRA is that comparisons are undertaken at least every 10 years, with a 5 year grace period. Consequently, the BIPM needs to be prepared to undertake an average of ten dosimetry comparisons and some twenty calibrations of national standards between CCRI meetings to enable the NMIs to maintain the degrees of equivalence of their national standards.

Table 2 shows the numbers of comparisons and calibrations made over the past few years. Although the necessary average numbers are being achieved, there is a small but

inevitable backlog of comparison reports, some sixteen at the moment that are pending, although some of these are at an advanced stage and should be published this year. A summary of the ^{137}Cs air kerma comparisons published in the past 10 years is also ready to be published [31] so that these results can also be entered into the key comparison database (KCDB).

Table 2 Number of BIPM comparisons and calibrations since 1992

Year	Comparisons	Calibrations
1992/1993	5	31
1994/1995	8	54
1996/1997	17	37
1998/1999	18	35
2000/2001	13	16
2002/2003	9	87
2004/2005	7	35
2006/2007	13	33
2008/2009	12	43
2010/2011 ^a	15	40

^a N.B. not a complete 24 months

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