Dosimetry comparisons and calibrations at the BIPM 2007 to 2009

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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, to date for 15 NMIs and the IAEA. The radiations used are low-energy (10 kV to 50 kV) and 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 100 TBq and 0.1 TBq, respectively), the smallest 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 7] while for those comparisons awaiting publication, draft reports are cited [8 to 20].

Thirteen comparisons (ten in terms of air kerma and three in terms of absorbed dose) and fifty-four calibrations of secondary standards have been carried out at the BIPM since the last meeting of Section I of the CCRI in 2007 (Table 1).

Collaboration has continued with the IAEA on periodic TLD irradiations at the ^{60}Co radiation quality.

The BIPM also participated in the CCRI(I)-S2 ^{60}Co high dose comparison at the lowest dose level of 1 kGy.

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

Two comparisons of air kerma standards using the CIS Bio ^{60}Co source have been carried out since the 2007 CCRI(I) meeting. These have been made with the NPL (United Kingdom) and the BEV (Austria) [12,16]; comparisons with the NRC (Canada) and VNIIM (Russian Federation) are scheduled for 2009. One comparison was made using the NBS radiation protection level source with the NPL [14].

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.

Although one earlier comparison report has now been published [7], three others are in various stages of preparation for publication [10, 12, 16] and should be completed in the near future.

Table 1 Comparisons and calibrations at the BIPM from May 2007 to April 2009

Year	Country	X-rays		^{137}Cs		^{60}Co		
		Air kerma 10 to 50 kV	Air kerma 100 to 250 kV	Air kerma	Ambient dose equivalent	Air kerma	Absorbed dose to water	Ambient dose equivalent
2007	France		**LNHB (3)**					
	Czech					CMI (1)	CMI (1)	
	UK	**NPL (3)**	**NPL (2)**	**NPL (1)**		**NPL (3)**	**NPL (2)**	
	Brazil		LNMRI (1)			LNMRI (1)	LNMRI (1)	
	South Africa		NMISA (2)			NMISA (2)	NMISA (2)	
2008	Mexico			ININ (1)		ININ (3)	ININ (2)	
	Sweden	SSI (2)	SSI (2)	SSI (1)		SSI (3)	SSI (2)	
	Australia	**ARPANSA (3)**						
	Greece		HIRCL (1)			HIRCL (1)	HIRCL (1)	
	Portugal			**ITN (1)**				
	IAEA			IAEA (2)	IAEA (1)	IAEA (2)		IAEA (1)
	France			**LNHB (1)**				
	Brazil		LNMRI (1)			LNMRI (1)	LNMRI (1)	
2009	Norway	NRPA (1)†	NRPA (1)	NRPA (2)	NRPA (1)	NRPA (4)	NRPA (2)	NRPA (1)
	Argentina		CRRD (1)			CRRD (1)	CRRD (1)	
	Austria			**BEV (2)**		**BEV (2)**	**BEV (2)**	
	Russia						**VNIIFTRI (2)**	
Measurements planned for 2009								
2009	Canada					**NRC**	**NRC**	
	Poland	**GUM**	**GUM**					
	Russia			**VNIIM**		**VNIIM**		
	France	**LNHB**						
	Japan						**NMIJ**	

CALIBRATIONS (number of chambers)
COMPARISONS (number of chambers)
†study note of a second chamber

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

Since the last Section I meeting, four comparisons of air kerma standards have been carried out using the ^{137}Cs source at the BIPM and the draft comparison reports are under discussion [8, 14, 15, 18].

In principle, the NIST (USA) and the MKEH (Hungary) should each undertake a new ^{137}Cs comparison in the near future and the ENEA (Italy) will each need to schedule a ^{137}Cs comparison before 2011. A comparison is planned for this year with the VNIIM.

The BIPM has been running Monte Carlo calculations to determine the correction factors that are appropriate for its cavity chamber standard in the ^{137}Cs beam. This work will be presented to the CCRI(I) in May 2009 and published shortly thereafter as the new realization of the reference beam for the air kerma standard.

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

Two low-energy x-ray comparisons of air kerma standards have been made since the last CCRI(I) meeting with the NPL and the ARPANSA (Australia). Comparisons with the GUM (Poland) and the LNE-LNHB (France) are planned for 2009.

The report for the comparison conducted in 2005 with the NMIJ (Japan) has been published [5].

Six NMIs will need to schedule new comparisons before the end of 2009 in order to comply with the recommendation for a fifteen-year cycle of comparisons (VSL (Netherlands), NIST, METAS (Switzerland), ENEA, VNIIM, PTB (Germany)).

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

Two comparisons of air kerma standards with the LNE-LNHB and the NPL have been made since the last CCRI(I) meeting. A comparison with the GUM is scheduled for 2009.

The reports for the comparisons with the NIM (China), BEV, LNE-LNHB and the VSL have been published [2, 3, 4, 6].

Five NMIs will need to schedule new comparisons before the end of 2009 in order to comply with the recommendation for a fifteen-year cycle of comparisons (ENEA, MKEH, NRC, VNIIM, PTB).

A study of the NIS (Eygpt) free-air chamber was also conducted prior to a future comparison [19].

6. Comparisons of absorbed dose standards for ^{60}Co

Three new comparisons of the absorbed dose standards in terms of absorbed dose to water have been made with the NPL, the BEV and the VNIIFTRI (Russian Federation) in the last two years. The comparisons were made using ionization chambers as transfer instruments [13, 17, 20].

Two other earlier comparison report are still to be finalized [9, 11] and then these results will be added to the KCDB.

Comparisons with the NRC and the NMIJ are scheduled for 2009.

There are now three participants (the NPL, ARPANSA and the METAS) with results in the absorbed dose comparison at high-energies, CCRI(I)-K6. The five transfer standards used in this comparison have also been measured periodically at the BIPM. The Draft A report has been delayed to make way for other priorities but with encouragement from the Accelerator Dosimetry Working Group should be written during the coming year.

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

Dosimetry calibrations have been made for Sweden, Brazil, South Africa, Greece, Norway, Argentina, Czech Republic, Mexico and the IAEA. Forty-one of the fifty-four secondary standard calibrations made at the BIPM since the last CCRI(I) meeting (Table 1) were re-calibrations. In general, the values are consistent with the statistical uncertainty of a calibration (0.07 %).

During a calibration for the IFIN (Mexico) the opportunity was taken to study the effects of low atmospheric pressure on the calibration coefficients for graphite and plastic walled ionization chambers. This work is continuing.

Following the implementation of the BIPM QS for dosimetry calibrations, two internal audits have been carried out since the last CCRI(I) meeting. The auditors declared satisfaction with the QS and no non-conformities were identified although some minor improvements have been implemented in accordance with suggestions. An external audit is scheduled to take place immediately after the CCRI meeting in May 2009.

8. Conclusion

Table 2 shows the numbers of comparisons, reports and calibrations made over the past few years.

With the recommendation made by the CCRI(I) under the CIPM MRA that comparisons are undertaken at least every 10 years, the BIPM needs to be prepared to undertake an average of 10 dosimetry comparisons and 20 calibrations between CCRI meetings to enable the NMIs to maintain the degrees of equivalence of their national standards.

Although this average has been achieved during the past two years, there is a small but inevitable backlog of comparison reports that are pending. However, a summary of the ^{60}Co air kerma comparisons published in the past 10 years has also been published [21].

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	7	43

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