Update of the BIPM comparison BIPM.RI(II)-K1.Cd-109 of activity measurements of the radionuclide ^{109}Cd to include the 2012 result of the LNE-LNHB (France)

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Abstract Since 1978, 10 laboratories have submitted 23 samples of ^{109}Cd to the International Reference System (SIR) for activity comparison at the Bureau International des Poids et Mesures (BIPM), with comparison identifier BIPM.RI(II)-K1.Cd-109. In 2012, the LNE-LNHB (France) participated in the comparison to update its degree of equivalence. A graphical presentation is also given.

1. Introduction

The SIR for activity measurements of γ-ray-emitting radionuclides was established in 1976. Each national metrology institute (NMI) may request a standard ampoule from the BIPM that is then filled with 3.6 g of the radioactive solution. For radioactive gases, a different standard ampoule is used. Each NMI completes a submission form that details the standardization method used to determine the absolute activity of the radionuclide and the full uncertainty budget for the evaluation. The ampoules are sent to the BIPM where they are compared with standard sources of ^{226}Ra using pressurized ionization chambers. Details of the SIR method, experimental set-up and the determination of the equivalent activity A_e, are all given in [1].

From its inception until 31 December 2020, the SIR has been used to measure 1021 ampoules to give 776 independent results for 72 different radionuclides. The SIR makes it possible for national laboratories to check the reliability of their activity measurements at any time. This is achieved by the determination of the equivalent activity of the radionuclide and by comparison of the result with the key comparison reference value determined from the results of primary standardizations. These comparisons are described as BIPM continuous comparisons and the results form the basis of the BIPM key comparison database (KCDB) of the Comité International des Poids et Mesures Mutual Recognition Arrangement (CIPM MRA) [2]. The comparison described in this report is known as the BIPM.RI(II)-K1.Cd-109 key comparison. The results of earlier participations in this key comparison were published previously [3, 4].

2. Participants

Laboratory details are given in Table 1, with the earlier submissions being taken from [3, 4]. The dates of measurement in the SIR given in Table 1 are used in the KCDB and all references in this report. The AECL (Atomic Energy of Canada Ltd) is not part of the NMI in Canada but was an invited participant in various SIR comparisons as, in the early years, J.G.V. Taylor of the AECL was a personal member of the predecessor to the CCRI(II).

Table 1: Details of the participants in the BIPM.RI(II)-K1.Cd-109.

NMI or laboratory	**Previous acronyms**	**Full name**	**Country**	**RMO**	**Date of SIR measurement** yyyy-mm-dd
AECL[a]	-	Atomic Energy of Canada Ltd	Canada	SIM	1982-03-31
BIPM	-	Bureau International des Poids et Mesures			1986-03-24
CMI-IIR	UVVVR	Czech Metrological Institute - Inspectorate for Ionizing Radiation	Czech Republic	EURAMET	1978-09-01 1986-04-08
IRA	IER	Institut de Radiophysique	Switzerland	EURAMET	2000-12-05
LNE-LNHB	LMRI, LPRI, BNM-LNHB	Laboratoire National de métrologie et d´Essais -Laboratoire National Henri Becquerel	France	EURAMET	1980-07-02 1998-01-23 2012-02-29
NIST	NBS	National Institute of Standards and Technology	United States	SIM	2004-11-22
NMIJ	ETL	National Metrology Institute of Japan	Japan	APMP	1996-04-05
NMISA	NAC, CSIR-NML[b]	National Metrology Institute of South Africa	South Africa	AFRIMETS	1978-04-18 1979-10-10 1981-03-24 1982-12-03
NPL	-	National Physical Laboratory	United Kingdom	EURAMET	1980-10-09

... Continuation of Table 1.

NMI or laboratory	Previous acronyms	Full name	Country	RMO	Date of SIR measurement yyyy-mm-dd
PTB	-	Physikalisch-Technische Bundesanstalt	Germany	EURAMET	1994-11-24 2004-09-24

[a] federal Crown corporation, not part of the NMI in Canada (see text)
[b] NAC is another institute of the country.

3. NMI standardization methods

Each NMI that submits ampoules to the SIR has measured the activity either by a primary standardization method or by using a secondary method, for example a calibrated ionization chamber. In the latter case, the traceability of the calibration needs to be clearly identified to ensure that appropriate correlations are taken into account.

A brief description of the standardization methods used by the laboratories, the activities submitted, the relative standard uncertainties and the half-life used by the participants are given in Table 2. The uncertainty budget for the new submission is given in Appendix D attached to this report; previous uncertainty budgets are given in the earlier K1 reports [3, 4]. The list of acronyms used to summarize the methods is given in Appendix E.

Since 2012, the half-life used by the BIPM is 461.9(4) days as published in BIPM Monographie 5 vol. 8 [5]. The half-life of 461.4(12) days [6] was used since 2004 and 464(1) days [7] for earlier results.

Table 2: Standardization methods of the participants for ^{109}Cd.

NMI or laboratory	Method used and the acronym	Activity A_i/MBq	Relative standard uncertainty /10^{-2}		Reference date	Half-life /d
			A	B	yyyy-mm-dd	
AECL	γ efficiency tracing using ^{109}Pd (4P-PC-BP-GL-GR-ET)	17 740	1.2	0.6	1981-09-01 17:00 UT	462.3(7)
BIPM	4π(PPC)ce (4P-PP-CE-00-00-00)	21 547[f] 21 708	0.01 0.01	0.26 0.26	1986-03-01 00:00 UT	462.6(4)
CMI-IIR	4π(NaI(Tl))x (4P-NA-XR-00-00-00)	3802	0.2	1.3	1978-07-27 11:00 UT	475
	4π(NaI(Tl))x (4P-NA-XR-00-00-00)	17 670	0.07	0.93	1986-03-19 12:00 UT	453.5

... Continuation of Table 2.

NMI or laboratory	**Method used and the acronym**	**Activity** A_i**/MBq**	**Relative standard uncertainty /10**$^{-2}$		**Reference date**	**Half-life /d**
			A	**B**	**yyyy-mm-dd**	
IRA	Ionization chamber (4P-IC-GR-00-00-00)[a]	51 320	0.08	0.61	2000-12-01 12:00 UT	462.9(20)
LNE-LNHB	4π(PPC)ce (4P-PP-CE-00-00-00)	2716[f] 2712	0.03 0.03	0.14 0.14	1980-02-19 00:00 UT	-
	TDCR (4P-LS-MX-00-00-TD) 4π(PPC)ce (4P-PP-CE-00-00-00)	6916[g]	0.99		1997-10-01 12:00 UT	-
	4π(NaI(Tl)) well-type counting (4P-NA-GR-00-00-00)	8731	0.05	0.94	2011-06-13 12:00 UT	461.4(12)
NIST	Ionization chamber (4P-IC-GR-00-00-00)[a]	42 410	0.04	0.51	2004-11-15 12:00 UT	462(1)
NMIJ	4π(PPC)ce (4P-PP-CE-00-00-00)	13 903	0.19	0.4	1996-03-01 12:00 UT	-
NMISA	4π(LS)ce-x coincidence (4P-LS-CE-NA-XR-CO)[b]	99 200[f] 101 800	0.11 0.11	2 2	1978-03-31 10:00 UT	
	4π(LS)ce-x coincidence (4P-LS-CE-NA-XR-CO)[b] 4π(LS)ce (4P-LS-CE-00-00-00)[b]	176 400[f] 187 900 176 800[f] 188 400	0.13 0.13 0.10 0.10	1.80 1.80 2.00 2.00	1979-09-28 13:00 UT	-
	4π(LS)ce-x coincidence (4P-LS-CE-NA-XR-CO)[c]	209 400[f] 212 100	0.1 0.1	1.82 1.82	1981-02-10 12:00 UT	
	4π(LS)ce-x coincidence (4P-LS-CE-NA-XR-CO)[c]	82 380[f] 79 930	0.03 0.03	0.71 0.71	1982-10-29 10:00 UT	
NPL	Ionization chamber (4P-IC-GR-00-00-00)[d]	39 300	0.09	1.64	1980-10-06 00:00 UT	
PTB	Ionization chamber (4P-IC-GR-00-00-00)[d]	7405	0.05	0.5	1994-10-01 00:00 UT	
	Ionization chamber (4P-IC-GR-00-00-00)[e]	14 962	0.06	0.29	2004-01-01 00:00 UT	[10]

[a] calibrated in 1986 against 4π(NaI(Tl))γ counting and 4π(LS)ce counting in the frame of the CCRI(II) comparison

[b] see details in [8]

[c] see details in [9]

[d] calibrated by a primary method

[e] calibrated in March 2005 by a combination of 4π(PPC)ce counting 4P-PP-CE-00-00-HE, LS counting 4P-LS-CE-00-00-00 and HPGe spectrometry UA-GH-GR-00-00-00

[f] Several samples submitted

[g] The result is the mean of the different methods.

Details regarding the solutions submitted are shown in Table 3, including any impurities, when present, as identified by the laboratories. When given, the standard uncertainties on the evaluations are shown.

Table 3: Details of each solution of ^{109}Cd submitted.

NMI or laboratory / SIR year	**Chemical composition**	**Solvent conc.** /(mol dm^{-3})	**Carrier conc.** /(µg g^{-1})	**Density** /(g cm^{-3})	**Relative activity of any impurity**[b]
AECL 1982	$CdCl_2$ in HCl	0.1	$CdCl_2$: 20	1	-
BIPM 1986[a]	$CdCl_2$ in HCl	0.1	$CdCl_2$: 20	-	^{110m}Ag: 3.6(7)x10^{-6} % ^{65}Zn: 1.4(3)x10^{-6} %
CMI-IIR 1978	$Cd(NO_3)_2$ in HCl	0.08	$Cd(NO_3)_2$: 50	-	<0.1 %
1986	$CdCl_2$ in HCl	0.08	$CdCl_2$: 50	-	<0.1 %
IRA 2000	$CdCl_2$ in HCl	0.1	$CdCl_2$: 20	1	negligible
LNE-LNHB 1980	$CdCl_2$ in HCl	1	$CdCl_2$: 25	1.016	^{110m}Ag: 0.082(2) % ^{60}Co: 0.0182(5) % ^{65}Zn: 0.0142(5) % ^{152}Eu: 0.0021(1) % ^{134}Cs: 0.0004(1) % ^{115m}Cd: 0.03(1) %
1998	$CdCl_2$ in HCl	1	$CdCl_2$: 10	1.016	-
2012	$CdCl_2$ in HCl	1	$CdCl_2$: 10	1.016	None detected
NIST 2004	$CdCl_2$ in HCl	0.5	$CdCl_2$: 500	1.007(1)	-
NMIJ 1996	$CdCl_2$ in HCl	0.1	$CdCl_2$: 200	1	^{65}Zn: 0.0047(5) %
NMISA 1978	CdCl in HCl	1	CdCl: 95	1.036	-
1979	$CdCl_2$ in HCl	1	$CdCl_2$: 100	1.036	-
1981	$CdCl_2$ in HCl	1	Cd^{++}: 610	1.037	-
1982	$CdCl_2$ in HCl	1	Cd^{++}: 300	1.037	-
NPL 1980	$CdCl_2$ in HCl	0.1	$CdCl_2$: 100	1.001	-
PTB 1994	$CdCl_2$ in HCl	0.1	$CdCl_2$: 45	1	-
2004	CdCl in HCl	0.1	CdCl: 28	1	-

[a] ampoules measured by the BIPM in the frame of the 1986 CCRI(II)-K2.Cd-109 and used to make the link for the CCRI(II) key comparison

[b] the ratio of the activity of the impurity to the activity of ^{109}Cd at the reference date

4. Results

All the submissions to the SIR since its inception in 1976 are maintained in a database known as the "master-file". The latest submission has added 1 ampoule for the activity measurements for ^{109}Cd giving rise to 23 ampoules in total. The SIR equivalent activity, A_{ei}, for each ampoule received from each NMI, i, including both previous and new results, is given in Table 4.

The relative standard uncertainties arising from the measurements in the SIR are also shown. This uncertainty is additional to that declared by the NMI ($u(A_i)$) for the activity measurement shown in Table 2. Although submitted activities are compared with a given source of ^{226}Ra, all the SIR results are normalized to the radium source number 5 [1].

No recent submission has been identified as a pilot study so the most recent result of each NMI is normally eligible for inclusion on the KCDB platform of the CIPM MRA [2].

In principle, the chemical composition of the solutions could have an influence on the SIR measurements due to the intense x-ray emission from ^{109}Cd. However, using the efficiency curve of the SIR [11], the contribution of the x rays to the ionization current is estimated to be negligible. In consequence, the influence of the chemical composition on the SIR measurements can also probably be neglected in this case although a more detailed study could be carried out.

Table 4: Results of SIR measurement of ^{109}Cd.

NMI or laboratory / SIR year	m_i /g	A_i /MBq	**^{226}Ra source**	A_{ei} /MBq	**Relative uncert. from SIR /10^{-4}**	u_{ci} /MBq	A_{ei} **for KCRV /MBq**
AECL 1982	1.613 23[a]	17 740	1	8110	28	110	8110(110)
BIPM 1986	3.605 6	21 547	1	8112	16	25	-
	3.632 5	21 708	1	8114	16	26	-
CMI-IIR 1978	3.596 5	3802[c]	1	7990	23	110	-[b]
1986	3.615 4	17 670	1	7913	25	77	-[b]
IRA 2000	3.527 60(10)	51 320	1	8065	14	51	8065(51)
LNE-LNHB 1980	3.685 56	2716[c]	1	8128	240[d]	200	-
	3.679 70	2712	1	8110	240	200	-
1998	3.594 4	6916[c]	1	8187	42	88	-
2012	3.757	8731[c]	1	8042	23	78	-
NIST 2004	3.613 9(2)	42 410	1	8168	16	44	-[e]
NMIJ 1996	3.594 3	13 903	1	8157	23	41	-
NMISA 1978	3.600	99 200	1	8161	13	160	-
	3.599	101 800	1	8164	13	160	-
1979	3.604	176 400	2	8217	11	150	-
	3.605	187 900	2	8214	11	150	-
	3.604	176 800	2	8238[h]	11	170	-
	3.605	188 400	2	8236[h]	11	170	-
1981	3.610	209 400	2	8186	11	150	-
	3.602	212 100	2	8187	11	150	-
1982	3.596	82 380	1	8166	20[f]	60	8171(60)[g]
	3.595	79 930	1	8175	21	60	-

... Continuation of Table 4.

NMI or laboratory / SIR year	m_i /g	A_i /MBq	^{226}**Ra source**	$A_{\mathrm{e}i}$ /MBq	**Relative uncert. from SIR** $/10^{-4}$	$u_{\mathrm{c},i}$ /MBq	A_{e} **for KCRV** /MBq
NPL 1980	3.589	39 300	1	8130	16	130	8130(130)
PTB 1994	3.698 9	7405[c]	1	8153[e]	37	51	-
2004	3.640 9(9)	14 962	1	8170	29	34	8170(34)

[a] mass of solution before dilution

[b] Result not included in the KCRV because of potential impurity in the solution (see details in [3].)

[c] Activity in the ampoule significantly lower than the minimum required for the SIR (45 MBq)

[d] the SIR uncertainty reflects the uncertainties of the impurity measurements reported by the NMI

[e] Result not included in the KCRV because of the slow drift of the ampoule holder's height in the IC at the NIST discovered in 2012

[f] changed from 14 x 10^{-4} to 20 x 10^{-4} and 21 x 10^{-4} due to the density effect in the SIR at low energy [12]

[g] An average value and average uncertainty between all submitted samples is used for the KCDB [13].

[h] unofficial result

4.1. The key comparison reference value

In May 2013, the CCRI(II) decided to calculate the key comparison reference value (KCRV) by using the power-moderated weighted mean [14] rather than an unweighted mean, as had been the policy. This type of weighted mean is similar to a Mandel-Paule mean in that the NMIs' uncertainties may be increased until the reduced chi-squared value is one. In addition, it allows for a power α smaller than two in the weighting factor. As proposed in [14], α is taken as $2 - 3/N$ where N is the number of results selected for the KCRV. Therefore, all SIR key comparison results can be selected for the KCRV with the following provisions:

(a) only results for solutions standardized by primary techniques are accepted, with the exception of radioactive gas standards (for which results from transfer instrument measurements that are directly traceable to a primary measurement in the laboratory may be included);

(b) each NMI or other laboratory may only use one result (normally the most recent result or the mean if more than one ampoule is submitted);

(c) results more than 20 years old are included in the calculation of the KCRV but are not included in data shown in the KCDB or in the plots in this report, as they have expired;

(d) possible outliers can be identified on a mathematical basis and excluded from the KCRV using the normalized error test with a test value of 2.5 and using the modified uncertainties;

(e) results can also be excluded for technical reasons; and

(f) the CCRI(II) is always the final arbiter regarding excluding any data from the calculation of the KCRV.

The data set used for the evaluation of the KCRVs is known as the KCRV file and is a reduced data set from the SIR master-file. Although the KCRV may be modified when other NMIs participate, on the advice of the Key Comparison Working Group of the CCRI(II), such modifications are made only by the CCRI(II) during one of its biennial meetings, or by consensus through electronic means (e.g., email) as discussed at the CCRI(II) meeting in 2013.

The ampoules containing an activity significantly smaller than the minimum required for the SIR were not selected for the KCRV. See Table 4. In addition, the 4π(PPC)ce method was not considered as primary for ^{109}Cd; the corresponding SIR results were also not selected for the KCRV. Consequently, using the recent result produces an updated KCRV for ^{109}Cd in 2012 of **8138(26) MBq** with the power α =1.4 that has been calculated using the previously published results, selected as shown in Table 4, for the NPL (1980), AECL (1982), NMISA (1982), IRA (2000), and the PTB (2004) result. This can be compared with the previous KCRV values of 8136(44) MBq published in 2003 [3].

4.2. Degrees of equivalence

Every participant in a comparison is entitled to have one result included in the KCDB as long as the NMI is a signatory or designated institute listed in the CIPM MRA and the result is valid (i.e., not older than 20 years). Normally, the most recent result is the one included. An NMI may withdraw its result only if all other participants agree.

The degree of equivalence of a given measurement standard is the degree to which this standard is consistent with the KCRV [2]. The degree of equivalence is expressed quantitatively in terms of the deviation from the key comparison reference value and the expanded uncertainty of this deviation ($k = 2$). The degree of equivalence between any pair of national measurement standards is expressed in terms of their difference and the expanded uncertainty of this difference and is independent of the choice of key comparison reference value.

4.2.1. Comparison of a given NMI result with the KCRV

The degree of equivalence of the result of a particular NMI, i, with the key comparison reference value is expressed as the difference D_i between the values

$$D_i = A_{ei} - \text{KCRV} \tag{1}$$

and the expanded uncertainty ($k = 2$) of this difference, U_i, known as the equivalence uncertainty; hence

$$U_i = 2u(D_i) \tag{2}$$

When the result of the NMI i is included in the KCRV with a weight w_i, then

$$u^2(D_i) = (1 - 2w_i)u_i^2 + u^2(\text{KCRV}) \tag{3}$$

However, when the result of the NMI i is not included in the KCRV, then

$$u^2(D_i) = u_i^2 + u^2(\text{KCRV}) \tag{4}$$

4.2.2. Comparison between pairs of NMI results

The degree of equivalence between the results of any pair of NMIs, i and j, is expressed as the difference D_{ij} in the values

$$D_{ij} = D_i - D_j = A_{\text{e}i} - A_{\text{e}j} \tag{5}$$

and the expanded uncertainty ($k = 2$) of this difference, $U_{ij} = 2u(D_{ij})$, where

$$u^2(D_{ij}) = u_i^2 + u_j^2 - 2u(A_{\text{e}i}, A_{\text{e}j}) \tag{6}$$

where any obvious correlations between the NMIs (such as a traceable calibration, or correlations normally coming from the SIR or from the linking factor in the case of linked comparison) are subtracted using the covariance $u(A_{\text{e}i}, A_{\text{e}j})$ (see [15] for more detail). However, the CCRI decided in 2011 that these pair-wise degrees of equivalence no longer need to be published as long as the methodology is explained.

Table B1 shows the matrix of all the degrees of equivalence as they will appear in the KCDB. It should be noted that for consistency within the KCDB, a simplified level of nomenclature is used with $A_{\text{e}i}$ replaced by x_i. The introductory text is that agreed for the comparison. The graph of the results in Table 5, corresponding to the degrees of equivalence with respect to the KCRV (identified as x_R in the KCDB), is shown in Figure C1. This graphical representation indicates in part the degree of equivalence between the NMIs but obviously does not take into account the correlations between the different NMIs. It should be noted that the final data in this paper, while correct at the time of publication, will become out-of-date as NMIs make new comparisons. The formal results under the CIPM MRA [2] are those available in the KCDB.

5. Conclusion

The BIPM continuous key comparison for ^{109}Cd, BIPM.RI(II)-K1.Cd-109, currently comprises 4 results. The results have been analyzed with respect to the updated KCRV, providing degrees of equivalence for 4 national metrology institutes. The degrees of equivalence have been approved by the CCRI(II) and are published in the BIPM key comparison database. Other results may be added when other NMIs contribute ^{109}Cd activity measurements to this comparison or take part in other linked comparisons.

6. References

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Appendix A. Introductory text for ^{109}Cd degrees of equivalence

Key comparison BIPM.RI(II)-K1.Cd-109

MEASURAND: Equivalent activity of ^{109}Cd

Key comparison reference value: the SIR reference value x_{R} for this radionuclide is 8138 MBq , with a standard uncertainty, u_{R} equal to 26 MBq (see Section 4.1 of the Final Report). The value x_i is taken as the equivalent activity for a laboratory i.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms: $D_i = (x_i - x_{\mathrm{R}})$ and U_i, its expanded uncertainty ($k = 2$), both expressed in MBq, and $U_i = 2((1 - 2w_i)u_i^2 + u_{\mathrm{R}}^2)^{1/2}$, where w_i is the weight of laboratory i contributing to the calculation of x_{R}.

Appendix B. Table of degrees of equivalence for BIPM.RI(II)-K1.Cd-109

Table B1: The table of degrees of equivalence for BIPM.RI(II)-K1.Cd-109

NMI i	D_i **/MBq**	U_i **/MBq**
IRA	-73	90
PTB	32	58
NIST	30	100
LNE-LNHB	-100	160

Appendix C. Graph of degrees of equivalence with the KCRV for ^{109}Cd (as it appears in Appendix B of the MRA)

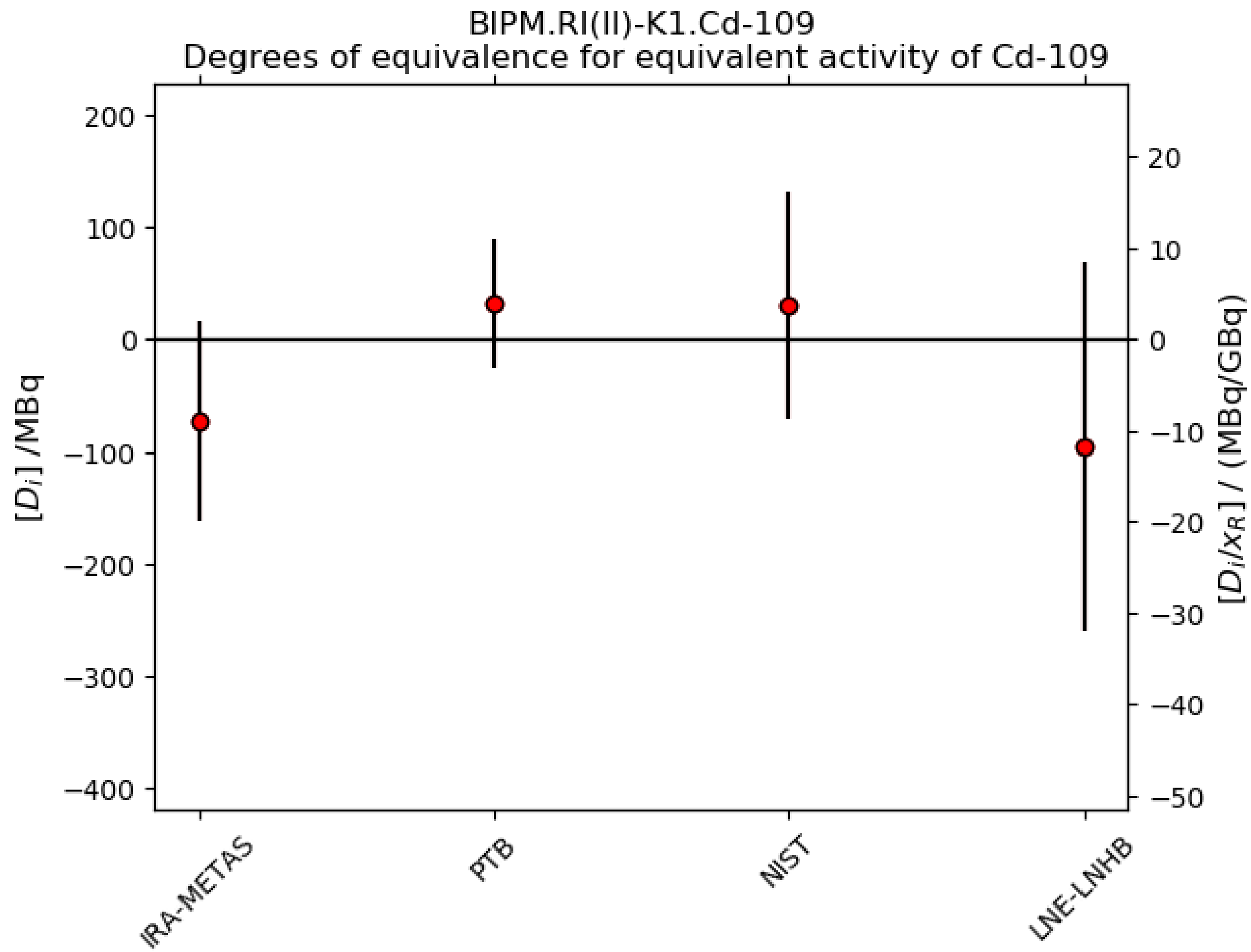

Figure C1. Degrees of equivalence for equivalent activity of ^{109}Cd.

Appendix D. Uncertainty budgets for the activity of ^{109}Cd submitted to the SIR

Detailed Uncertainty Budget

Laboratory: **LNE-LNHB**; Radionuclide: **^{109}Cd** _ ; Ampoule number: **3**

*Uncertainty components**, in % of the activity concentration, due to

		Remarks	Evaluation type (A or B)	Relative Sensitivity Factor
counting statistics	**0.3**	**10 sources measured**	**B**	—
weighing	**0.1**	**Pycnometer technique**	**B**	—
dead time	**0.01**	**Live-time technique**	**B**	—
background	**0.05**	—	**A**	—
pile-up	—	—	—	—
counting time	—	—	—	—
adsorption	—	—	—	—
impurities	—	—	—	—
tracer	—	—	—	—
input parameters and statistical model	—	—	—	—
quenching	—	—	—	—
interpolation from calibration curve	—	—	—	—
Detection efficiency	**0.2**	**GEANT4 MC code**	**B**	
decay-scheme parameters	**0.7**	—	**B**	—
half life (**$T_{1/2}$: 461.4 (12) d**)	**0.01** —	**Decay correction**	**B**	—
self absorption	—	—	—	—
extrapolation of efficiency curve	**0.5** —	**Detection threshold setting**	**B** —	—
other effects (if relevant) (geometry factor, retrodiffusion)	—	—	**B** —	—
combined uncertainty (as quadratic sum of all uncertainty component	**0.94**	—	—	—

* The uncertainty components are to be considered as approximations of the corresponding standard deviations (see also *Metrologia*, 1981, 17, 73 and *Guide to expression of uncertainty in measurement*, ISO, corrected and reprinted 1995).

Appendix E. Acronyms used to identify different measurement methods

Each acronym has six components, geometry-detector (1)-radiation (1)-detector (2)-radiation (2)-mode. When a component is unknown, ?? is used and when it is not applicable 00 is used.

Geometry	**acronym**	**Detector**	**acronym**
4 π	4P	proportional counter	PC
defined solid angle	SA	press. Prop. Counter	PP
2 π	2P	liquid scintillation counting	LS
undefined solid angle	UA	NaI(Tl)	NA
		Ge(HP)	GH
		Ge(Li)	GL
		Si(Li)	SL
		CsI(Tl)	CS
		ionization chamber	IC
		grid ionization chamber	GC
		Cerenkov detector	CD
		calorimeter	CA
		solid plastic scintillator	SP
		PIPS detector	PS
		CeBr3	CB

Radiation	**acronym**	**Mode**	**acronym**
positron	PO	efficiency tracing	ET
beta particle	BP	internal gas counting	IG
Auger electron	AE	CIEMAT/NIST	CN
conversion electron	CE	sum counting	SC
mixed electrons	ME	coincidence	CO
bremsstrahlung	BS	anti-coincidence	AC
gamma rays	GR	coincidence counting with efficiency tracing	CT
x-rays	XR	anti-coincidence counting with efficiency tracing	AT
photons ($x + \gamma$)	PH	triple-to-double coincidence ratio counting	TD
photons + electrons	PE	selective sampling	SS
alpha particle	AP	high efficiency	HE
mixture of various radiation	MX	digital coincidence counting	DC

Examples of methods	**acronym**
4π(PC)β-γ coincidence counting	4P-PC-BP-NA-GR-CO
4π(PPC)β-γ coincidence counting eff. trac	4P-PP-MX-NA-GR-CT
defined solid angle α-particle counting with a PIPS detector	SA-PS-AP-00-00-00
4π(PPC)AX-γ(GeHP)-anticoincidence counting	4P-PP-MX-GH-GR-AC
4πCsI-β,AX,γ counting	4P-CS-MX-00-00-HE
calibrated IC	4P-IC-GR-00-00-00
internal gas counting	4P-PC-BP-00-00-IG