Update of the BIPM comparison BIPM.RI(II)-K1.I-131 of activity measurements of the radionuclide ^{131}I to include the 2015 results of the BEV (Austria) and the POLATOM (Poland), the 2017 result of the NMISA (South Africa), and to link the CCRI(II)-S6.I-131 comparison

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Abstract

Three new participations in the BIPM.RI(II)-K1.I-131 comparison have been added to the previous results and this has produced a revised value for the key comparison reference value (KCRV), calculated using the power-moderated weighted mean. A link has been made to the CCRI(II)-S6.I-131 comparison piloted by the International Atomic Energy Agency (IAEA) in 2006, based on the participation of CMI-IIR in both comparisons. One NMI used the S6 comparison to update its degree of equivalence. The results of two NMIs in the CCRI(II)-S6.I-131 comparison were superseded by a more recent APMP.RI(II)-K2.I-131 comparison. The degrees of equivalence between each equivalent activity measured in the International Reference System (SIR) and the KCRV have been calculated and the results are given in the form of a table for the latest results in the BIPM.RI(II)-K1.I-131, and the linked CCRI(II)-S6.I-131, APMP.RI(II)-K2.I-131 and EURAMET.RI(II)-K2.I-131 comparisons. 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 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

[#] Pilot of the 2006 CCRI(II)-S6.I-131 comparison, as a Consultant to the IAEA

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 2021, the SIR has measured 1033 ampoules to give 788 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 ongoing comparisons and the results form the basis of the BIPM key comparison database (KCDB) of the CIPM Mutual Recognition Arrangement (CIPM MRA) [2]. The comparison described in this report is known as the BIPM.RI(II)-K1.I-131 key comparison and includes results published previously [3 - 6].

In addition, an international comparison piloted by the International Atomic Energy Agency (IAEA) was held in 2006 for this radionuclide, CCRI(II)-S6.I-131 [7]. Seven laboratories took part in this comparison from which four are signatories/designated institutes of the MRA. A link to the SIR has been evaluated thanks to the participation of the Český Metrologický Institut (CMI, Czechia) in both comparisons. The LNMRI/IRD had previously participated in the SIR and has updated its result through this CCRI(II) comparison.

A further two international comparisons linked to the SIR, APMP.RI(II)-K2.I-131 and EURAMET.RI(II)-K2.I-131, were held in 2009 and 2015, respectively. Linked degrees of equivalence were already published in [6] and [15].

2. Participants in the BIPM.RI(II)-K1.I-131

In addition to the ampoules submitted by the BEV and NMISA, which replace their earlier SIR submissions, the POLATOM has submitted one ampoule for inclusion in this comparison. The details of the laboratories that have participated in the BIPM.RI(II)-K1 comparison are given in Table 1a, with the earlier submissions being taken from [3 - 6]. In cases where the laboratory has changed its name since the original submission, both the earlier and the current acronyms are given, as it is the latter that is used in the KCDB. The date of measurement in the SIR is also given in Table 1a and is used in the KCDB and all references in this report.

Table 1a. Details of the participants in the BIPM.RI(II)-K1.I-131

NMI	Original acronyms or other institutes	Full name	Country	Regional metrology organization	Date of measurement at the BIPM
NIST	NBS	National Institute of Standards and Technology	United States	SIM	1977-05-24 1978-06-05 1979-09-03 1980-03-06 1981-03-06 1998-02-04 2012-03-28
PTB	ASMW*	Physikalisch-Technische Bundesanstalt	Germany	EURAMET	1978-03-10 1989-10-31 1993-03-15 2004-04-30
BARC	–	Bhabha Atomic Research Centre	India	APMP	1979-07-17 1994-06-15
NMISA	NAC§	National Metrology Institute, South Africa	South Africa	AFRIMET	1980-02-11 2017-09-13
NPL	–	National Physical Laboratory	United Kingdom	EURAMET	1980-10-08 1999-03-18
BKFH	OMH MKEH	Government Office of the Capital City Budapest	Hungary	EURAMET	1983-03-04 1991-11-25 1998-10-28
IRA	IER	Institut de Radiophysique Appliquée	Switzerland	EURAMET	1984-05-24 1996-09-19
PTKMR	PDS	Pusat Teknologi Keselamatan dan Metrologi Radiasi	Indonesia	APMP	1985-06-17
NMIJ	ETL	National Metrology Institute of Japan	Japan	APMP	1986-02-05 2009-03-09
CMI	UVVVR CMI-IIR	Český Metrologický Institut -Inspectorate for Ionizing Radiation	Czech Republic	EURAMET	1986-10-02 2001-09-25 2006-08-22

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Table 1a continued. Details of the participants in the BIPM.RI(II)-K1.I-131

NMI	Original acronyms or other institutes	Full name	Country	Regional metrology organization	Date of measurement at the BIPM
LNE-LNHB	LMRI	Bureau national de métrologie-Laboratoire national Henri Becquerel	France	EURAMET	1987-06-22 2012-11-16
–	NIRH	National Institute of Radiation Hygiene	Denmark	EURAMET	1991-03-27
ANSTO	–	Australian Nuclear Science and Technology Organisation	Australia	APMP	1994-06-02
LNMRI /IRD	–	Laboratorio Nacional de Metrologia das Radiaçoes Ionizantes/Instituto de Radioproteção e Dosimetria	Brazil	SIM	1999-11-17
CIEMAT	–	Centro de Investigaciones Energéticas, Medioambientales y Tecnològicas	Spain	EURAMET	2002-06-26
IFIN-HH	–	Institutul de Fizica si Inginerie Nucleara-Horia Hulubei	Romania	EURAMET	2005-11-28 2008-01-03
KRISS	–	Korea Research Institute of Standards and Science	Republic of Korea	APMP	2005-12-23
BEV	–	Bundesamt für Eich- und Vermessungswesen	Austria	EURAMET	2007-05-23 2015-06-02
POLATOM	–	National Centre for Nuclear Research Radioisotope Centre	Poland	EURAMET	2015-10-22

* a previous standards laboratory in the country
§ NAC is another institute in the country now named iThemba LABS

The NMIs that took part in the CCRI(II) international comparison, CCRI(II)-S6.I-131 organized by the Comité Consultatif des Rayonnements Ionisants – section II and piloted by the IAEA in 2006 [7] and who are eligible for the KCDB are shown in Table 1b including the CMI, the linking laboratory.

Table 1b. Details of the participants in the 2006 CCRI(II)-S6.I-131 eligible for linking to BIPM.RI(II)-K1.I-131 comparison

NMI	Full name	Country	Regional metrology organization
BARC*	Bhaba Atomic Research Centre	India	APMP
CMI[§]	Český Metrologický Institut	Czechia	EURAMET
IFIN-HH**	Institutul de Fizica si Inginerie Nucleara - "Horia Hulubei"	Romania	EURAMET
LNMRI/IRD	Laboratorio Nacional de Metrologia das Radiaçoes Ionizantes/ Instituto de Radioproteção e Dosimetria	Brazil	SIM

* Participation superseded by a more recent APMP.RI(II)-K2.I-131 comparison
** Participation superseded by a more recent SIR submission
[§] Linking laboratory; the full acronym in 2006 was CMI-IIR

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 any correlations are taken into account.

A brief description of the standardization methods, the activities submitted, the relative standard uncertainties ($k = 1$) and the half-life used by the participants in the SIR are given in Table 2. The uncertainty budgets for the three new submissions are given in Appendix 1a, previous uncertainty budgets are given in the earlier K1 reports [3–6]. The uncertainty budgets for the eligible participants in the CCRI(II)-S6.I-131 comparison are given in Appendix 1b. The acronyms used for the measurement methods are given in Appendix 2.

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 2. Standardization methods of the SIR participants for ^{131}I

NMI	Method used and acronym (see Appendix 2)	Half-life / d	Activity A_i / kBq	Reference date YYYY-MM-DD	Relative standard uncertainty × 100 by method of evaluation	
					A	B
NIST	Pressurized IC 4P-IC-GR-00-00-00 calibrated by 4πβ(PC) 4P-PC-BP-00-00-00	–	7 170 7 190[a]	1977-05-11 17 h UT	0.02	0.57
		8.02(1)	4 648	1978-05-24 12 h UT	0.01	0.63
	Pressurized IC 4P-IC-GR-00-00-00 calibrated in 1979 by 4πβ-γ coincidence 4P-PP-BP-NA-GR-CO	8.02(1)	4 475	1979-07-17 19 h UT	0.01	0.64
			4 395	1980-02-21 7 h UT	0.01	0.61
			5 363[b]	1981-02-24 20 h UT	0.04	0.47
			19 850	1998-01-27 22 h UT	0.02	0.35
	4πβ-γ anti-coinc. 4P-LS-BP-NA-GR-AC	8.0233(19) [8]	17 460	2012-03-06 20 h UT	0.09	0.31
PTB	Pressurized IC [d] 4P-IC-GR-00-00-00	–	32 160	1978-03-08 0 h UT	0.01	0.15
	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	–	4 005	1989-11-01 12 h UT	0.01	0.15
	Pressurized IC [d] 4P-IC-GR-00-00-00	–	3 719 3 708[a]	1993-03-12 0 h UT	0.03	0.20
	Pressurized IC 4P-IC-GR-00-00-00 calibrated in 2004 by 4πβ-γ coinc. and 4P-PC-BP-NA-GR-CO CIEMAT/NIST 4P-LS-MX-00-00-CN	8.0207(9)	43 222 43 139[a]	2004-05-05 0 h UTC	0.04	0.18
BARC	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	–	1 901	1979-07-05 6 h 30 UT	0.19	0.43
		–	259.2	1994-06-01 6 h 30 UT	0.11	0.29

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Table 2 continued. Standardization methods of the participants for ^{131}I

NMI	Method used and acronym (see Appendix 2)	Half-life / d	Activity A_i / kBq	Reference date	Relative standard uncertainty × 100 by method of evaluation	
				YYYY-MM-DD	A	B
NMISA	4π(LS)β-γ coinc. 4P-LS-BP-NA-GR-CO	–	22 510 22 580[a]	1980-02-06 10 h UT	0.03	0.50
		8.0233(19)	27 733	2017-08-16 10 h UT	0.04	0.37
NPL	Pressurized IC [e] 4P-IC-GR-00-00-00	–	6 899	1980-10-06 0 h UT	0.06	0.33
	4π(PPC)-γ coinc. 4P-PP-BP-NA-GR-CO	–	3 750 3 719[a]	1999-03-02 12 h UT	0.09	0.27
MKEH	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	8.020(2) [10]	3 702	1983-03-08 12 h	0.02	0.63
		8.021(1) [11]	10 140	1991-12-01 12 h UT	0.02	0.39
	4π(PC)-γ coinc. 4P-PC-BP-NA-GR-CO	8.021(1) [11]	9 398	1998-10-27 0 h UT	0.02	0.31
IRA	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	–	3 634	1984-05-16 0 h UT	0.04	0.49
	Pressurized IC [d] 4P-IC-GR-00-00-00	–	3 453	1996-09-10 10 h UT	0.03	0.50
PTKMR	Pressurized IC 4P-IC-GR-00-00-00	–	2 360 2 360[a]	1985-06-06 2 h UT	1.1	
NMIJ	4π(PC)β-γ coinc. 4P-PC-BP-NA-GR-CO	8.040	2 822 2 809[a]	1986-02-04 12 h UT	0.08	0.26
		8.0233	3 208	2009-03-20 0 h UT	0.24	0.03
CMI	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	8.02	20 290	1986-10-01 12 h UT	0.04	0.27
	Pressurized IC [d] 4P-IC-GR-00-00-00	8.021(1)	9 701	2001-09-18 12 h UT	0.28	0.28
	4π(PC)β-γ coinc. 4P-PC-BP-NA-GR-CO	8.0233(19) [8]	73 260	2006-07-12 10 h UT	0.10	0.26

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Table 2 continued. Standardization methods of the participants for ^{131}I

NMI	Method used and acronym (see Appendix 2)	Half-life / d	Activity A_i / kBq	Reference date YYYY-MM-DD	Relative standard uncertainty × 100 by method of evaluation	
					A	B
LNE-LNHB	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	8.021 (1)	2 116 2 114[a]	1987-06-24 12 h UT	0.10	0.13
	4πβ-γ anti-coincidence 4P-PC-BP-NA-GR-AC	8.0233(19) [8]	21 390	2012-11-12 12 h UT	0.10	0.39
	4πγ counting 4P-NA-GR-00-00-HE		21 375		0.23	0.09
NIRH	Pressurized IC 4P-IC-GR-00-00-00	–	67 200	1991-03-20 23 h UT	0.5	2.5
ANSTO	Pressurized IC [c] 4P-IC-GR-00-00-00	–	6 491	1994-05-17 23 h UT	0.02	0.88
LNMRI /IRD	Pressurized IC [f] 4P-IC-GR-00-00-00	8.021(1) [11]	11 610	1999-11-01 0 h UT	0.18	0.43
CIEMAT	4π(PC)β-γ (NaI) coincidence 4P-PC-BP-NA-GR-CO	8.021	35 940	2002-06-05 10 h UT	0.45	0.10
IFIN-HH	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	8.021	2 845	2005-11-14 12 h UT	0.2	0.5
		8.0233(19) [8]	3 057	2007-11-29 12 h UT	0.2	0.22
KRISS	4πβ-γ coincidence 4P-PC-BP-NA-GR-CO	8.0233(19) [8]	17 366	2005-12-15 0 h UT	0.04	0.22
BEV	Pressurized IC [g] 4P-IC-GR-00-00-00	8.021	3 102	2007-05-25 0 h UT	0.07	0.37
		8.0233	1 400.3	2015-06-01 0 h UT	0.06	0.39
POLATOM	4π(LS)β-γ coinc. 4P-LS-BP-NA-GR-CO/AC	8.0233(19) [8]	846.9	2015-10-20 12 h UT	0.09	0.36

[a] two ampoules submitted
[b] corrected for the growth of ^{131m}Xe which was assumed to be zero at the time of sealing the ampoule
[c] calibrated by 4πβ-γ coincidence measurements of ^{131}I in1978
[d] traceable to 4πβ-γ coincidence measurements 4P-PC-BP-NA-GR-CO of ^{131}I (in 2001 for the CMI)
[e] calibrated by primary measurements of ^{131}I
[f] calibrated by 4πβ-γ coincidence measurements of ^{131}I in1993
[g] traceable to NPL

Table 3. Details of the solution of ^{131}I submitted

NMI		Chemical composition	Solubilization medium[9] conc.	Carrier conc. /(μg g^{-1})	Density /(g cm^{-3})	Relative activity of impurity†
NIST	1977	KI and Na_2SO_3 in diluted LiOH and NaOH	LiOH: 1.3×10^{-3} mol dm^{-3} NaOH: 0.05×10^{-3} mol dm^{-3} Na_2SO_3: 30 μg g^{-1}	KI: 60	0.999 (2)	^{125}I : 0.3 % *
	1978		LiOH: 0.1×10^{-3} mol dm^{-3} NaOH: 0.08×10^{-3} mol dm^{-3} Na_2SO_3: 3 μg g^{-1}	KI: 6	0.999 (2)	–
	1979				0.998 (2)	–
	1980	KI and Na_2SO_3 in diluted $LiOH.H_2O$ and NaOH	$LiOH.H_2O$: 0.05×10^{-3} mol dm^{-3} NaOH: 0.01×10^{-3} mol dm^{-3} Na_2SO_3: 2 μg g^{-1}	KI: 5	0.998 (2)	–
	1981		$LiOH.H_2O$: 0.07×10^{-3} mol dm^{-3} NaOH: 0.02×10^{-3} mol dm^{-3} Na_2SO_3: 3 μg g^{-1}	KI: 6	0.998 (2)	–
	1998	KI in LiOH	LiOH : 0.01 mol dm^{-3}	KI: 68	0.999	–
	2012	KI, Na_2SO_3 in diluted LiOH	Na_2SO_3: 70 μg g^{-1} LiOH: 234 μg g^{-1}	KI: 156	0.999	^{131m}Xe: 0.36 (15) % *

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Table 3 continued. Details of the solution of ^{131}I submitted

NMI		Chemical composition	Solubilization medium[9] conc.	Carrier conc. /(μg g^{-1})	Density /(g cm^{-3})	Relative activity of impurity†
PTB	1978	NaI and $Na_2S_2O_3$ in water with 0.1 % Formalin	water with 0.1 % Formalin $Na_2S_2O_3$: 100 μg g^{-1}	NaI: 100	1.00	< 0.01 %
	1989	KI and $Na_2S_2O_3$ in water	$Na_2S_2O_3$: 50 μg g^{-1}	KI: 20	0.9982	< 0.03 %
	1993	NaI and $Na_2S_2O_3$ and 0.1 % Formalin in NaOH	NaOH: 1 mol dm^{-3} with 0.1 % Formalin $Na_2S_2O_3$: 45 μg g^{-1}	NaI: 60	1.0	–
	2004	NaI and $Na_2S_2O_3$ in HCHO (formaldehyde)	HCHO: 0.04 mol dm^{-3} $Na_2S_2O_3$: 45 μg g^{-1}	NaI: 60	1.00	–
BARC	1979	KI and $Na_2S_2O_3$ in water	$Na_2S_2O_3$: 60 μg g^{-1}	KI: 200	–	–
	1994	NaI and $Na_2S_2O_3$ in water		KI: 100	1	–
NMISA	1980	KI and Na_2SO_3 in diluted NaOH	NaOH: 0.2 × 10^{-3} mol dm^{-3} Na_2SO_3: 1600 μg g^{-1}	KI: 4800	1.007	–
	2017	NaI and $NaIO_3$ in water		–	1.0	–
NPL	1980	KI in NaOH	NaOH: 0.01 mol dm^{-3}	KI: 100	1.0004	–
	1999	NaI and $Na_2S_2O_3$ in diluted NaOH	NaOH: 0.0025 mol dm^{-3} $Na_2S_2O_3$: 25 μg g^{-1}	NaI: 55	1	–
MKEH	1983	KI; KIO_3 and $Na_2S_2O_3$ in water	$Na_2S_2O_3$: 50 μg g^{-1}	KI: 50 KIO_3 : 50	–	< 0.01 %
	1991				–	–
	1998	I in NaOH	NaOH: 0.01 mol dm^{-3}	–	–	–

Table continued next page

Table 3 continued. Details of the solution of ^{131}I submitted

NMI	Chemical composition	Solubilization medium[9] conc.	Carrier conc. /(μg g^{-1})	Density /(g cm^{-3})	Relative activity of impurity†
IRA 1984	KI and Na_2SO_3 in diluted LiOH	LiOH: 0.9×10^{-3} mol dm^{-3} Na_2SO_3 : 20 μg g^{-1}	KI: 50	1.00	–
1996			KI: 20	–	–
PTKMR 1985	KI and Na_2SO_3 in diluted LiOH	LiOH: 0.9×10^{-3} mol dm^{-3} Na_2SO_3 : 20 μg g^{-1}	KI: 50	0.990 (1)	–
NMIJ 1986	NaI and Na_2SO_3 in diluted LiOH	LiOH: 0.9×10^{-3} mol dm^{-3} Na_2SO_3 : 30 μg g^{-1}	NaI: 50	0.9982	–
2009#	NaI and $Na_2S_2O_3$ in diluted LiOH	LiOH: 20 μg g^{-1} $Na_2S_2O_3$: 20 μg g^{-1}	NaI: 50	1.000 09	–
CMI 1986	KI and $Na_2S_2O_3$ in $NaHCO_3$	$NaHCO_3$ 0.7×10^{-3} mol dm^{-3} $Na_2S_2O_3$: 50 μg g^{-1}	KI: 50	–	< 0.1 %
2001	KI and $Na_2S_2O_3$ in water	$Na_2S_2O_3$: 50 μg g^{-1}	KI: 50	–	< 0.1 %
2006###	KI and $Na_2S_2O_3$ in $NaHCO_3$	$NaHCO_3$: 0.5×10^{-3} mol dm^{-3} $Na_2S_2O_3$: 50 μg g^{-1}	KI: 50	–	–
LNE-LNHB 1987	KI and $Na_2S_2O_3$ in diluted NaOH	NaOH: 0.5×10^{-3} mol dm^{-3} $Na_2S_2O_3$: 50 μg g^{-1}	KI: 50	0.9983	$< 2 \times 10^{-3}$ %
2012	NaI and $Na_2S_2O_3 \cdot 5H_2O$ in water	$Na_2S_2O_3 \cdot 5H_2O$: 2×10^{-4} mol dm^{-3}	NaI: 50	1.000	–
NIRH 1991	–	–	–	1	–
ANSTO 1994	NaI	–	–	–	–

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Table 3 continued. Details of the solution of ^{131}I submitted

NMI	Chemical composition	Solubilization medium[9] conc.	Carrier conc. /(μg g^{-1})	Density /(g cm^{-3})	Relative activity of impurity†
LNMRI/IRD 1999	NaCl in water	–	–	1.01	–
CIEMAT 2002	Na_2HPO_4 in water	Na_2HPO_4: 6800 μg g^{-1}	–	–	–
IFIN-HH 2005	NaI and $Na_2S_2O_3$ in NaOH	NaOH: 0.01 mol dm^{-3} $Na_2S_2O_3$: 80 μg g^{-1}	NaI: 50	1	^{131m}Xe: 2.69 (45) % *
2008	NaI and $Na_2S_2O_3$ in NaOH	NaOH: 0.01 mol dm^{-3} $Na_2S_2O_3$: 80 μg g^{-1}	NaI: 50	1	–
KRISS 2005	NaI in NaOH	NaOH: 0.1 mol dm^{-3}	NaI: 100	1.0012	–
BEV 2007	NaI and $Na_2S_2O_3$ in HCHO	HCHO: 0.04 mol dm^{-3} $Na_2S_2O_3$: 130 μg g^{-1}	NaI: 60	1.00	–
2015		HCHO: 1.2 g dm^{-3} $Na_2S_2O_3$: 127 μg g^{-1}	NaI: 60	1	–
POLATOM 2015##	NaI and $Na_2S_2O_3$ in HCHO	HCHO: 0.3 mol dm^{-3} $Na_2S_2O_3$: 50 μg g^{-1}	NaI: 65	1.004	^{133}I: < 2.9 × 10^{-4} % * ^{135}I: < 1.0 × 10^{-8} % *

† the ratio of the activity of the impurity to the activity of ^{131}I at the reference date
* negligible effect on the SIR measurement
# same solution as for the 2009 APMP.RI(II)-K2.I-131 comparison
same solution as for the 2015 EURAMET.RI(II)-K2.I-131 comparison
same solution as for the 2006 CCRI(II)-S6.I-131 comparison

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 submissions have added three ampoules for the activity measurements for ^{131}I giving rise to 48 ampoules in total. The SIR equivalent activity, A_{ei}, for each ampoule for the previous and new results is given in Table 4a for each NMI, *i*. The relative standard uncertainty arising from the measurements in the SIR is also shown. This uncertainty is additional to that declared by the NMI 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].

The half-life used by the BIPM, in the CCRI(II)-S6 and EURAMET.RI(II)-K2 comparisons is 8.0233(19) d from the BIPM Monographie 5 [8]. As the half-life of the daughter radionuclide ^{131m}Xe ($T_{1/2}$ of 11.93 d [6]) is longer than that of the parent, no transient equilibrium can be reached. However, the contribution of ^{131m}Xe to the SIR ionization current is negligible for a period of up to about 8 weeks after the source production, because of the low branching ratio and gamma-emission probability.

Measurements repeated at the BIPM after periods of up to 10 days later produced comparison results in agreement within the standard uncertainty for the BEV(2015) and for the POLATOM(2015) and the NMISA(2017).

The BEV(2015) and NMISA(2017) results agree within standard uncertainty with their earlier SIR result.

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

Table 4a. Results of SIR measurements of ^{131}I

NMI	Mass of solution m_i / g	Activity submitted A_i / kBq	N° of Ra source used	SIR A_e / kBq	Relative uncertainty from SIR	Combined uncertainty $u_{c,i}$ / kBq
NIST	3.665 65	7 170	3	40 780	8×10^{-4}	240
1977	3.676 07	7 190		40 790		240
1978	3.671 13	4 648	2	40 700	9×10^{-4}	260
1979	3.620 48	4 475	1	40 160	24×10^{-4}	280
1980	3.611 43	4 395	2	40 380	10×10^{-4}	250
1981	3.580 17	5 363	3	40 340	7×10^{-4}	190
1998	3.596 14	19 850	4	40 510	8×10^{-4}	150
2012	3.592 12	17 460	3	40 340	7×10^{-4}	140

Table continued next page

Table 4a continued. Results of SIR measurements of ^{131}I

NMI	Mass of solution m_i / g	Activity submitted A_i / kBq	N° of Ra source used	SIR A_e / kBq	Relative uncertainty from SIR	Combined uncertainty $u_{c,i}$ / kBq
PTB 1978	3.682 7(1)	32 160	5	40 392	6×10^{-4}	66
1989	3.511 6	4 005	3	40 533	7×10^{-4}	67
1993	3.641 8	3 719	3	40 416	7×10^{-4}	85
	3.631 0	3 708		40 352		85
2004	3.6115(9)	43 222	5	40 372	6×10^{-4}	77
	3.6045(9)	43 139		40 342†		77
BARC 1979	3.599 7	1 901	1	40 450	13×10^{-4}	200
1994	3.585 2	259.2	1	40 380	23×10^{-4} §	160
NMISA 1980	3.649	22 510	4	40 440	6×10^{-4}	200
	3.585 *	22 580		40 430†		200
2017	3.66012	27 733	2	40 550	9×10^{-4}	160
NPL 1980	3.701 4	6 899	3	40 320	7×10^{-4}	140
1999	3.721 70	3 750	2	40 210	10×10^{-4}	120
	3.690 49	3 719		40 150†	9×10^{-4}	120
MKEH 1983	3.604 4	3 702	3	40 010	8×10^{-4}	260
1991	3.610 8	10 140	4	40 420	6×10^{-4}	160
1998	3.617 4	9 398	4	40 330	7×10^{-4}	130
IRA 1984	3.584 7(1)	3 634	3	40 320	7×10^{-4}	200
1996	3.363 6(1)	3 453	2	40 270	10×10^{-4}	210
PTKMR 1985	3.575	2 360	2	40 260	9×10^{-4}	440
	3.574	2 360		40 200	10×10^{-4}	440
NMIJ 1986	3.602 6	2 822	3	40 320	8×10^{-4}	110
	3.586 5	2 809		40 320	7×10^{-4}	110
2009[a]	3.599 74	3 208	4	40 430	7×10^{-4}	100
CMI 1986	3.588 0	20 290	3	40 330	6×10^{-4}	110
2001	3.610 4	9 701	3	40 640	7×10^{-4}	170
2006[b]	3.596 6	73 260	2	40 370	13×10^{-4}	120
LNE-LNHB 1987	3.623 94	2 116	3	40 313	7×10^{-4}	72
	3.621 13	2 114		40 298	8×10^{-4}	72
2012	3.642	21 380(47)#	4	40 184	6×10^{-4}	92
NIRH 1991	3.316	67 200	5	40 200	6×10^{-4}	1000

Table continued next page

Table 4a continued. Results of SIR measurements of ^{131}I

NMI	Mass of solution m_i / g	Activity submitted A_i / kBq	N° of Ra source used	SIR A_e / kBq	Relative uncertainty from SIR	Combined uncertainty $u_{c,i}$ / kBq
ANSTO 1994	3.584	6 491	2	40 410	10×10^{-4}	360
LNMRI /IRD 1999	3.510 04	11 610	3	40 690	8×10^{-4}	190
CIEMAT 2002	3.546 3	35 940	3	40 150	8×10^{-4}	190
IFIN-HH 2005	3.604 29	2 845	2	39 814	12×10^{-4}	220
2008	3.293 00	3 057	1	40 410	18×10^{-4}	140
KRISS 2005	3.61344	17 366	4	39 962	7×10^{-4}	91
BEV 2007	3.603 7	3 102	3	40 540	7×10^{-4}	160
2015	3.596	1400.3	2	40 710	11×10^{-4}	170
POLATOM 2015[c]	3.6189	846.9	1	40 270	14×10^{-4}	160

[†] the mean of the two A_e values is used with an averaged uncertainty, as attributed to an individual entry [14].
* mass of active solution before dilution: 1.188 28 g and 1.192 01 g, respectively.
[#] weighted mean value and standard uncertainty of the two results obtained with two different methods given in Table 2
[§] mainly type A uncertainty because the current measured in the SIR was only about 0.7 pA.
[a] results used to link the 2009 APMP.RI(II)-K2 comparison
[b] results used to link the 2006 CCRI(II)-S6 comparison
[c] results used to link the 2015 EURAMET.RI(II)-K2 comparison

An international comparison for this radionuclide, CCRI(II)-S6.I-131, was held in 2006 [7] and the three laboratories from this comparison to be added to the matrix of degrees of equivalence are given in Table 1b, together with the CMI participation that served to link the comparison to the BIPM.RI(II)-K1 comparison. The LNMRI/IRD used the CCRI(II) comparison to update its degree of equivalence from earlier SIR participation. The BARC and IFIN-HH results in the CCRI(II) comparison are superseded by a more recent participation in the APMP.RI(II)-K2 comparison and the SIR, respectively.

The results $(A/m)_i$ of the CCRI(II) comparison have been linked to the BIPM.RI(II)-K1.I-131 comparison through the measurement in the SIR of one ampoule of the CCRI(II) solution standardized by the CMI. The linking factor L_j is defined to be

$$L_j = A_{e,j} / (A/m)_j = 1.9818 \text{ g} \qquad \text{(a)}$$

where the activity (kBq), mass (g) and equivalent activity (kBq) are taken from the row indicated in Table 4a for the CMI (2006), with A recalculated at the S6 reference date. The relative uncertainty of this additional decay correction is 1.4×10^{-4} as is therefore

negligible. So, the relative standard uncertainty of L_j is 13×10^{-4}, the uncertainty from the SIR measurement of the linking ampoule, also given in Table 4a.

The linked results are evaluated as

$$A_{ei} = (A/m)_i \, L_j$$

where the primary activity concentration measured by the participants in the CCRI(II)-S6 comparison are taken from the Final report [7] and are shown in Table 4b. The uncertainties for the CCRI(II) comparison results linked to the SIR are comprised of the original uncertainties combined quadratically with the uncertainty in the link.

Table 4b. Results of the 2006 CCRI(II)-S6 comparison of ^{131}I including CMI, the linking laboratory

NMI	Measurement method and acronym (see Appendix 2 and [7])	Activity* concentration measured $(A/m)_i$ / (MBq g^{-1})	Standard uncertainty u_i / (MBq·g^{-1})	Equivalent SIR activity A_{ei} / kBq	Combined standard uncertainty u_i / kBq
BARC**	4P-PC-BP-NA-GR-CO 4P-IC-GR-00-00-00 §	37.12 37.2	0.17 0.5	40 190	190
IFIN-HH**	4P-IC-GR-00-00-00 calibrated by 4πβ−γ coincidence counting	37.75	0.13	40 870	150
LNMRI /IRD	4P-IC-GR-00-00-00 calibrated by 4πβ−γ coincidence counting	37.1	0.5	40 160	540
CMI	4P-PC-BP-NA-GR-CO 4P-IC-GR-00-00-00 §	37.29# 37.15	0.10 0.33	40 370	120

*referenced to 10:00 UTC 5 July 2006
** participation superseded by another participation in a more recent comparison
§ Ionization chamber calibrated by 4πβ−γ coincidence counting, not used for equivalence
& Ionization chamber calibrated by third party or using third-party calibration source, not used for equivalence
# same primary result as for the SIR comparison, with a different reference date. The earlier published result of 37.03(10) MBq g^{-1} [7] is probably inaccurate due to a reference time or time zone mix-up at the CMI.

A bilateral activity comparison, EURAMET.RI(II)-K2.I-131 was held in 2015 and enabled the ENEA-INMRI (Italy) to be linked to the SIR using the POLATOM result in Table 4a. The linking factor and linked result have already been published [15]. Although the published linked result of 40 290(170) kBq for ENEA-INRIM is correct, confusion between A and A/m happened in the linking formula (4) of the comparison publication, that should read

$$A_{\mathrm{e,\ ENEA\text{-}INMRI}} = 172.104 \, (A/m)_{\mathrm{ENEA\text{-}INMRI}} \, .$$

4.1 The Key Comparison Reference Value

In May 2013 the CCRI(II) decided to calculate the key comparison reference value (KCRV) using the power-moderated weighted mean [12] 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 [12], 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 has only 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.

Consequently, the KCRV for ^{131}I has been calculated to be 40 371(34) kBq with the power α = 1.81 on the basis of the SIR results from the IRA(1984), ASMW(1989), ANSTO, BARC(1994), BKFH(1998), NPL(1999), LNMRI/IRD(1999), CIEMAT, PTB(2004), CMI-IIR(2006), IFIN-HH(2008), NMIJ(2009), NIST(2012), the LNE-LNHB(2012) and the recent results of the POLATOM(2015) and the NMISA(2017). The KRISS SIR result is identified as an outlier. This updated value can be compared with the previous KCRVs of 40 390(40) kBq published in 2003 [3], 40 400(4) kBq published in 2008 [5] and 40 370(35) kBq published in 2014 [6], and has been approved by the CCRI(II).

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 result of the PTKMR in the 2006 APMP.RI(II)-K2.I-131 comparison has been included in the present report because this laboratory is now a designated institute in Indonesia.

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

$$D_i = A_{\mathrm{e}\,i} - \mathrm{KCRV} \qquad (1)$$

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

$$U_i = 2u(D_i)\,. \qquad (2)$$

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

$$u^2(D_i) = (1\text{-}2w_i)\,u_i^2 + u^2(\mathrm{KCRV})\,. \qquad (3)$$

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

$$u^2(D_i) = u_i^2 + u^2(\mathrm{KCRV}). \qquad (4)$$

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

$$D_{ij} = D_i - D_j = A_{\mathrm{e}\,i} - A_{\mathrm{e}\,j} \qquad (5)$$

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

$$u_{D\,ij}{}^2 = u_i{}^2 + u_j{}^2 - 2u(A_{\mathrm{e}i}, A_{\mathrm{e}j}) \qquad (6)$$

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 $u(A_{\mathrm{e}i}, A_{\mathrm{e}j})$ (see [13] 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 5 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_{ei} 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 1. 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.

Conclusion

The BIPM ongoing key comparison for ^{131}I, BIPM.RI(II)-K1.I-131, currently comprises ten valid results. The key comparison reference value has been updated using the power-moderated weighted mean to include the POLATOM and NMISA latest results.

The result of the LNMRI/IRD that took part in the CCRI(II)-S6.I-131 comparison in 2006 has been linked to the BIPM ongoing key comparison, superseding its earlier result from the BIPM.RI(II)-K1.I-131 comparison.

The SIR results together with the previously published APMP.RI(II)-K2.I-131 and EURAMET.RI(II)-K2.I-131 results, have been analysed with respect to the updated KCRV determined for this radionuclide.

Eighteen degrees of equivalence in total have been approved by the CCRI(II) and are published in the BIPM key comparison database. Further results may be added when other NMIs contribute ^{131}I activity measurements to the ongoing K1 comparison or take part in other linked comparisons.

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Table 5. Table of degrees of equivalence and introductory text for ^{131}I

Key comparison BIPM.RI(II)-K1.I-131

MEASURAND : **Equivalent activity of ^{131}I**

Key comparison reference value: the SIR reference value x_R for this radionuclide is 40 371 kBq, with a standard uncertainty u_R of 34 kBq (see section 4.1 of the Final report). The value x_i is taken as the equivalent activity for laboratory i.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms: $D_i = (x_i - x_R)$ and U_i, its expanded uncertainty ($k = 2$), both expressed in MBq, and $U_i = 2((1 - 2w_i)u_i^2 + u_R^2)^{1/2}$ when each laboratory has contributed to the calculation of x_R.

Linking APMP.RI(II)-K2.I-131 to BIPM.RI(II)-K1.I-131

The value x_i is the equivalent activity for laboratory i participant in APMP.RI(II)-K2.I-131 having been normalized using the value of the NMIJ as the linking laboratory.

The degree of equivalence of laboratory i participant in APMP.RI(II)-K2.I-131 with respect to the key comparison reference value is given by a pair of terms: $D_i = (x_i - x_R)$ and U_i, its expanded uncertainty ($k = 2$), both expressed in MBq. The approximation $U_i = 2(u_i^2 + u_R^2)^{1/2}$ is used in the following table as none of these D_i contributed to the KCRV.

Linking CCRI(II)-S6.I-131 to BIPM.RI(II)-K1.I-131

The value x_i is the equivalent activity for laboratory i participant in CCRI(II)-S6.I-131 having been normalized using the value of the CMI as the linking laboratory.

The degree of equivalence of laboratory *i* participant in CCRI(II)-S6.I-131 with respect to the key comparison reference value is given by a pair of terms: $D_i = (x_i - x_R)$ and U_i, its expanded uncertainty ($k = 2$), both expressed in MBq.
The approximation $U_i = 2(u_i^2 + u_R^2)^{1/2}$ is used in the following table as none of these D_i contributed to the KCRV.

Linking EURAMET.RI(II)-K2.I-131 to BIPM.RI(II)-K1.I-131

The value x_i is the equivalent activity for laboratory *i* participant in EURAMET.RI(II)-K2.I-131 having been normalized to the value of the POLATOM as the linking laboratory.

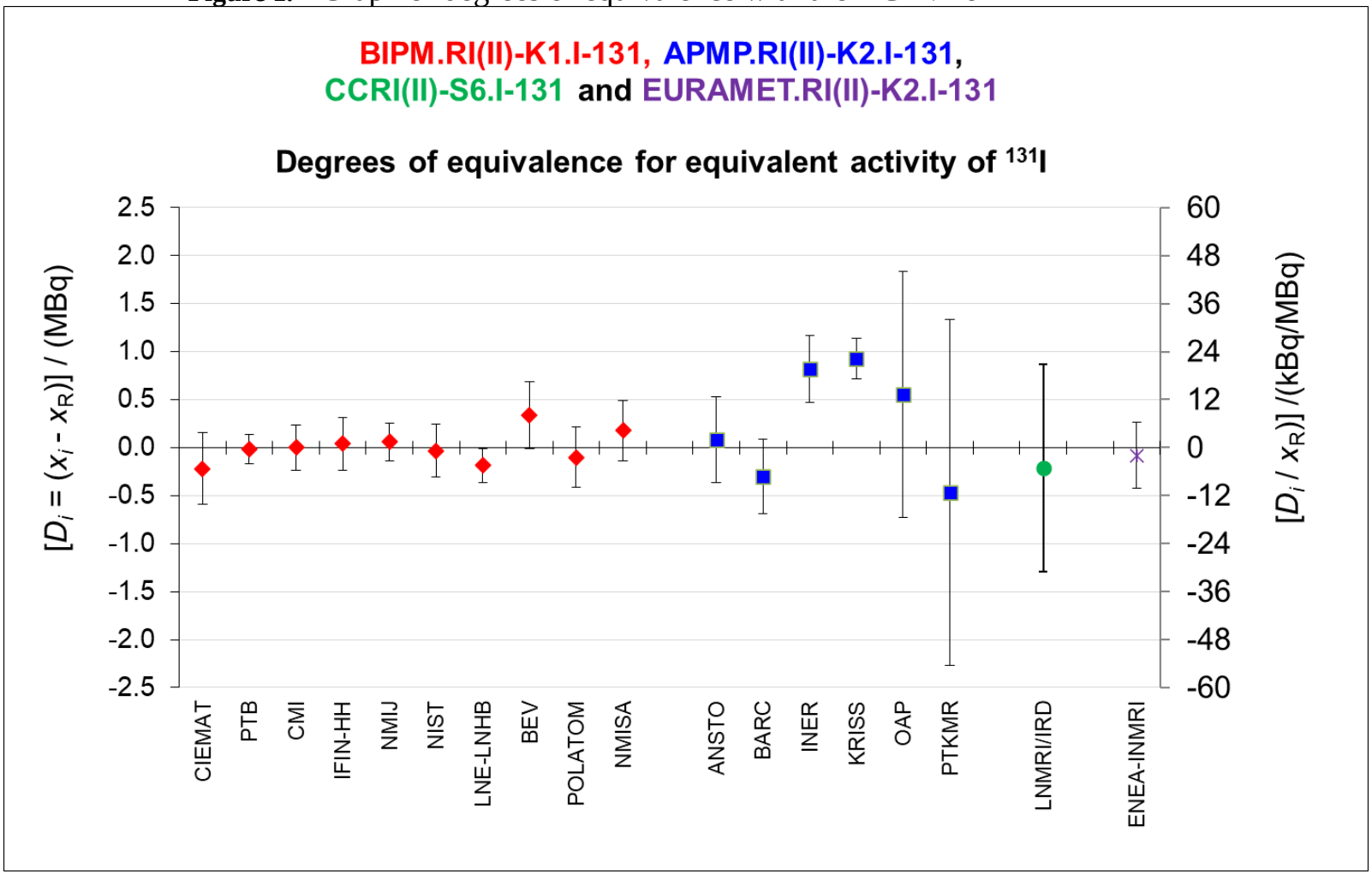
The degree of equivalence of laboratory *i* participant in EURAMET.RI(II)-K2.I-131 with respect to the key comparison reference value is given by a pair of terms: $D_i = (x_i - x_R)$ and U_i, its expanded uncertainty ($k = 2$), both expressed in MBq.
The approximation $U_i = 2(u_i^2 + u_R^2)^{1/2}$ is used in the following table as none of these D_i contributed to the KCRV.

These statements make it possible to extend the BIPM.RI(II)-K1.I-131 matrices of equivalence to the participants in CCRI(II)-S6.I-131.

Lab *i* BIPM.RI(II)-K1	D_i / MBq	U_i / MBq
CIEMAT	-0.22	0.37
PTB	-0.01	0.15
CMI	0.00	0.23
IFIN-HH	0.04	0.27
NMIJ	0.06	0.19
NIST	-0.03	0.27
LNE-LNHB	-0.19	0.18
BEV	0.34	0.35
POLATOM	-0.10	0.31
NMISA	0.18	0.31

Lab *i* APMP.RI(II)-K2	D_i / MBq	U_i / MBq
ANSTO	0.08	0.45
BARC	-0.30	0.39
INER	0.82	0.35
KRISS	0.93	0.21
OAP	0.5	1.3
PTKMR	-0.5	1.8
CCRI(II)-S6		
LNMRI/IRD	-0.2	1.1
EURAMET.RI(II)-K2		
ENEA-INMRI	-0.08	0.35

Figure 1. Graph of degrees of equivalence with the KCRV for ^{131}I



N.B. The right-hand axis shows approximate values only

Appendix 1a. Uncertainty budgets for the activity of ^{131}I submitted to the SIR

Detailed Uncertainty Budget

Laboratory: BEV Radionuclide: I-131 Ampoule number: SIR 2015 I-131

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

		Remarks	Evaluation type (A or B)	Relative sensitivity Factor
counting statistics	0,06	_____	A	9,97E-1
weighing	0,006	_____	B	-1,02E+0
background	included into current measurement			
half life ($T_{1/2}$ = 8,0233 d ; u = 0,0019 d)	0,06	_____	B	2,47E+2
other effects (if relevant) (explain)	0,33	calibration factor	B	-1,00E+00
	0,12	current measurement	B	1,00E+00
	0,12	ionisation chamber	B	1,00E+00
	0,12	filling height	B	1,00E+00
combined uncertainty (as quadratic sum of all uncertainty components)	0,39	k= 1		

Detailed Uncertainty Budget

Laboratory: *Laboratory of Radioactivity Standards, Radioisotope Centre POLATOM, National Centre for Nuclear Research*

Radionuclide: ^{131}I; Ampoule number: *BW/30/15-18*

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

		Remarks	Evaluation type (A or B)
counting statistics	*0.087*		*A*
weighing	*0.19*		*B*
dead time	*0.001*		*B*
background			
pile-up			
counting time	*0.001*		*B*
adsorption			
impurities			
tracer			
input parameters and statistical model			
quenching			
interpolation from calibration curve			
decay-scheme parameters			
half life ($T_{1/2}$ = *8.0233 d*; *u* = *0.0019 d*)	*0.012*		*B*
self absorption			
extrapolation of efficiency curve	*0.3*		*B*
other effects (if relevant) (explain)	*0.012*	*coincidence gate*	*B*
combined uncertainty (as quadratic sum of all uncertainty components)	*0.366*		

Detailed Uncertainty Budget

Laboratory: **NMISA**; Radionuclide: ^{131}**I**; Ampoule number: **NMISA I-131 SIR 2017**.

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

		Remarks	Evaluation type (A or B)	Relative Sensitivity Factors
counting statistics	0.04	Standard deviation of the mean of 24 values	A	0.2
weighing	0.03	Mass for primary source prep.	B	1
	0.01	Mass for SIR ampoule prep.	B	1
dead time	0.01	$\Delta\tau_D \pm 0.05$ µs	B	0.001
background	0.02	Background square root statistics applied	B	0.003
counting time	0.001	Calibration of timer	B	1
impurities	0.0	HPGe measurements	B	1
decay correction using half-life	0.002	8.0233 (0.0019) days from Chisté and Bé (2016)	B	0.09
efficiency extrapolation	0.2	Relative difference between 1st O and 2nd O polynomials	B	1
Coincidence resolving time	0.01	$\Delta\tau_R \pm 0.01$ µs	B	0.006
Afterpulse correction	0.04	Based on formula for $\Delta\theta$	B	0.002
Adsorption	0.02	Count rates after multiple rinsings relative to the expected count rates if rinsings were not done	B	1
Build-up of Xe-131m	0.3	Fraction of Xe-131m after 6 days	B	1
combined uncertainty (as quadratic sum of all uncertainty components)	**0.37**	_ _ _ _ _	_ _	_ _ _

* 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 1b. Uncertainty budgets for the activity of ^{131}I in the 2006 CCRI(II)-S6.I-131 comparison

Uncertainty budget for **LNMRI/IRD** (4P-IC-GR-00-00-00)

Relative standard uncertainties	u_i x 10^4 Evaluated by method	
Contributions due to	**A**	**B**
Repeatability	7	-
Background	0. 8	-
Decay correction (time determination)	-	0.1
Uncertainty in reference source	-	0.02
Linearity	-	100
Calibration factor	-	84
Mass measurement for transfer to “standard geometry”	-	5
Scale resolution	-	9
Decay correction (half-life)	-	6
Quadratic summation	7	131
Combined standard uncertainty	131	

Appendix 2. 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**
4π	4P	proportional counter	PC
defined solid angle	SA	press. prop counter	PP
2π	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
		$CeBr_3$	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 + γ)	PH	triple-to-double coincidence ratio counting	TD
alpha - particle	AP	selective sampling	SS
mixture of various radiation	MX	high efficiency	HE

Examples **method**	**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(Ge(HP))-anticoincidence counting	4P-PP-MX-GH-GR-AC
4π CsI-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