Update of KCRVs for the BIPM.RI(II)-K1 key comparison series

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The rules for the selection of data for the KCRV, originally defined by the CCRI(II) in 2001, are as follows:

The key comparison reference value is derived from the unweighted mean of all the results submitted to the SIR with the following provisions:

a) only primary standardized solutions are accepted[1], 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) any outliers are identified using a reduced chi-squared test and, if necessary, excluded from the KCRV using the normalized error test with a test value of four;

d) exclusions must be approved by the CCRI(II).

1. KCRV updates published since the last CCRI(II) meeting

Since the last CCRI(II) meeting in 2005, seven key comparison reference values have been updated. In most cases, the update followed the decision taken by the CCRI(II) in 2005 and some more recent SIR results for the same radionuclides that fulfilled the criteria above were also included at the same time. In addition, for two radionuclides for which the KCRV was based on only a few results (^{18}F and ^{99}Tc^{m}), the decision to update the KCRV was approved by e-mail. Finally, for ^{222}Rn, a KCRV has been published for the first time because a second result, from the PTB, became available. These updates are described in Table 1.

The LNE-LNHB ^{67}Ga result is the lowest value for this radionuclide. However, it was included in the KCRV because it passed the normalized error (NE k = 4) exclusion test. It is interesting to note that the three lowest ^{67}Ga degrees of equivalence are those based on anti-coincidence counting. Differences depending on the standardization method and type of dead-time used may be related to the ^{67}Zn meta-stable state (9 μs) populated by the ^{67}Ga decay[2]. In addition, the decay scheme of this radionuclide shows discrepancies. It should be noted that, in this case, the SIR efficiency curve does not help in discriminating in favour of any particular measurement method as the ^{67}Ga photon emission probabilities have uncertainties that are too large. A new evaluation of the ^{67}Ga decay scheme, taking into account the Bobin et al 2007 publication, would be very useful.

In 2005, the CCRI(II) agreed to update the KCRV for ^{131}I and ^{22}Na to include results from the PTB and the BARC respectively. However, as other NMIs later submitted ampoules to the

[1] Ionization chamber measurements that are directly traceable to a primary measurement in the laboratory were included in KCRVs up to December 2005.

[2] Bobin et al., 2007, Standardization of ^{67}Ga using a 4π(LS)-γ anti-coincidence system, *Appl. Radiat. Isotop.*, in press.

SIR for these radionuclides (IFIN, KRISS and CMI-IIR for ^{131}I; CIEMAT and PTB for ^{22}Na), the updates have been postponed to incorporate the new values for which the criteria are fulfilled. In addition, it appeared necessary to update the ^{131}I half-life used in the SIR from 8.021 (1) d to 8.0233 (19) d.

In November 2006, the KCWG discussed the case of ^{131}I. Considering that the IFIN and the KRISS are planning to submit new ^{131}I ampoules in 2007 to supersede their 2005 results, the KCWG recommended postponing the inclusion of additional results in the KCRV for this radionuclide and to maintain the decision made by the CCRI(II) in 2005.

Table 1. KCRV updates published since last CCRI(II) meeting

Radionuclide	**Old KCRV / kBq**	***u*(KCRV) / kBq**	**New KCRV published / kBq**	***u*(KCRV) / kBq**	**Year**	**NMI included**
^{18}F	15 245	32	15 259	29	2005	PTB
^{67}Ga	116 040	520	116 190	560	2006	CIEMAT LNE-LNHB#
^{60}Co	7 064.6	3.8	7 061.3	3.5	2006	CNEA RC NIST(1980)* IRMM#
^{99}Tc^{m}	153 070	460	153 140	330	2005	NPL#
^{137}Cs	27 549	44	27 534	42	2005	IRMM NMIJ
^{139}Ce	132 870	170	132 740	100	2005	NMIJ
^{222}Rn	–	–	9 961	53	2006	IRA# PTB#

inclusion approved by CCRI(II) by e-mail
* to replace NIST (1997) ionization chamber result

2. Proposals for KCRV updates

New proposals for updating the KCRVs are summarized in Table 2. All these updates are based on recently published SIR results except for ^{133}Ba and ^{134}Cs for which the latest reports are not yet published.

From all the recently published SIR results eligible to be included in the KCRV, none has been excluded. In the case of ^{134}Cs, the latest CNEA result is in much better agreement with the other participants. Consequently, applying the NE $k = 4$ exclusion test on all the ^{134}Cs results enables the LNMRI to be identified as a third outlier (in addition to KRISS and CIEMAT). The new KCRV seems now more robust as it is based on less scattered data (see Figure 1). In addition, it is now in close agreement with the SIRIC efficiency curve value (10 120 (10) kBq).

Table 2. Proposals for KCRV updates

Radionuclide	**Old KCRV / kBq**	***u*(KCRV) / kBq**	**NMI to be included**	**Year**	**Proposed KCRV / kBq**	***u*(KCRV) / kBq**
^{22}Na	7 526	5	BARC § ANSTO § CIEMAT # PTB #	2004 1981 2006 2006	7530	6
^{51}Cr	487 440	540	NPL NMIJ	2004 2004	487 540 487 920*	470 320*
^{57}Co	168 700	400	PTB	2005	168 740	400
$^{99}Tc^{m}$	153 140	330	PTB	2005	153 000	340
^{109}Cd	$8\ 136 \times 10^3$	14×10^3	PTB NIST	2004 2004	$8\ 141 \times 10^3$	13×10^3
^{111}In	43 000	120	PTB	2005	43 070	130
^{131}I	40 390	40	PTB	2004	40 387 §§	43 §§
^{133}Ba	43 965	68	IFIN # NMIJ #	2005 2006	43 932	67
^{134}Cs	10 096	16	IRMM PTB MKEH LNE-LNHB NMIJ BARC # CNEA #	2004 2004 2004 2005 2005 2005 2005	10 116 **	13 **
^{237}Np	–	–	PTB IRMM	2006 2006	74 850	110
^{241}Am	$2\ 053.7 \times 10^3$	3.3×10^3	NPL VNIIM	2002 2006	$2\ 054.3 \times 10^3$ $2\ 055.8 \times 10^3$ ##	2.8×10^3 2.8×10^3 ##

§ already agreed by CCRI(II) in 2005.
§§ already agreed by CCRI(II) in 2005; ^{131}I half-life updated. See text.
* if IRMM is not selected for the KCRV. See text.
** LNMRI excluded. See text.
\# results not yet published.
\## if MKEH (1979) is not selected for the KCRV. See text.

The use in the KCRV of the 1981 result of the IRMM for ^{51}Cr seems questionable because the ampoule contained a mass of solution (ca 2.87 g) significantly lower than the 3.6 g requested. In addition, the IRMM result is the lowest value for that radionuclide. Consequently, it is proposed to exclude this result from the KCRV which then becomes 487.92 (32) MBq (see Figure 2). It should be noted that, in this case, the SIR efficiency curve does not help in discriminating in favour of any proposed KCRV as the ^{51}Cr photon emission probabilities have uncertainties that are too large.

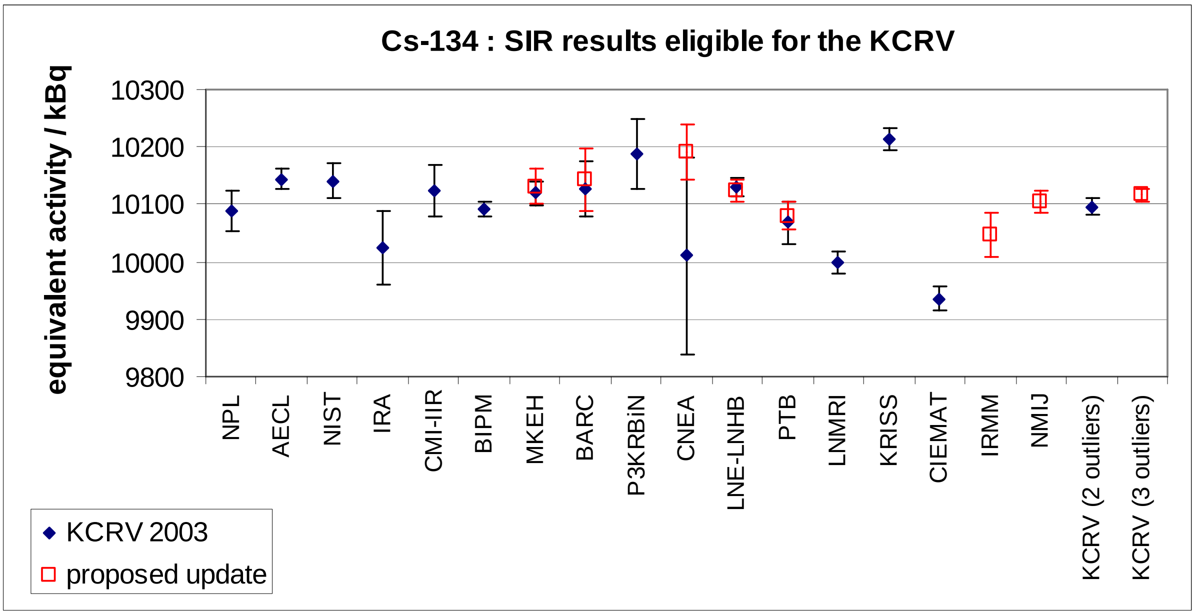

Figure 1. ^{134}Cs SIR results eligible for the KCRV. Uncertainties shown are at $k = 1$.

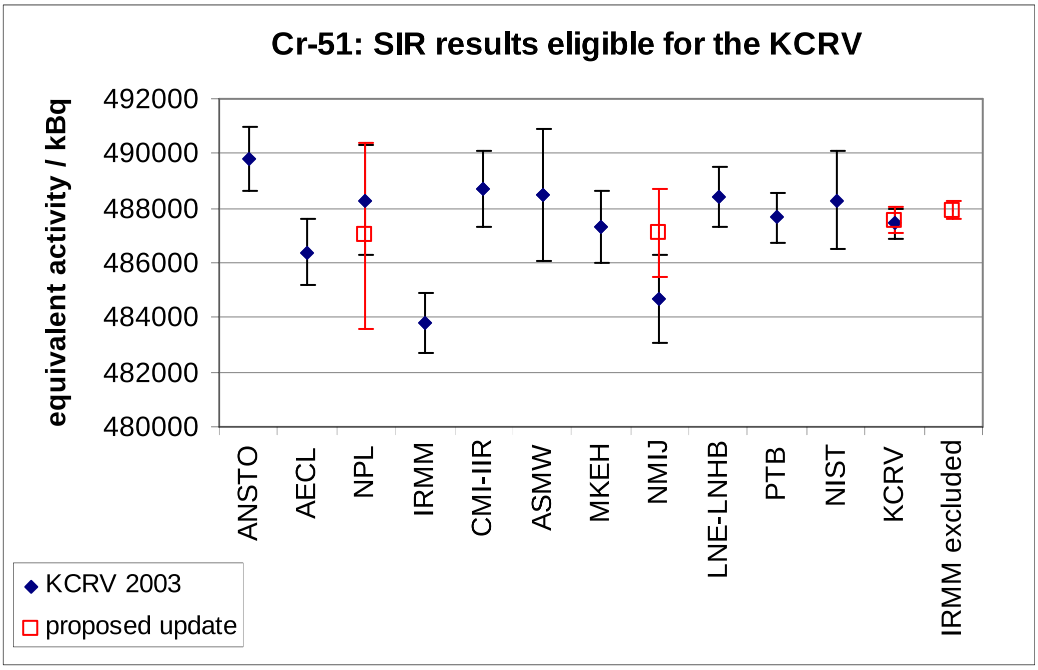

Figure 2. ^{51}Cr SIR results eligible for the KCRV. Uncertainties shown are at $k = 1$.

For ^{241}Am, the correction for density applied to the SIR results seems not to be applicable in the case of the 1979 MKEH ampoule that contains only 3.28 cm^3 of solution (see the BIPM.RI(II)-K1.Am-241 2007 update report). Indeed, the 1979 MKEH result is the lowest value for that radionuclide (see Figure 3) while the MKEH result in the recent CCRI(II)-K2 comparison is much closer to the KCRV. Consequently, it is proposed to exclude this result from the KCRV, which then becomes 2 055.8 (2.8) × 10^3 kBq. Again in this case, the SIR efficiency curve does not help in discriminating in favour of any proposed KCRV as the ^{241}Am photon emission probabilities have uncertainties that are too large.

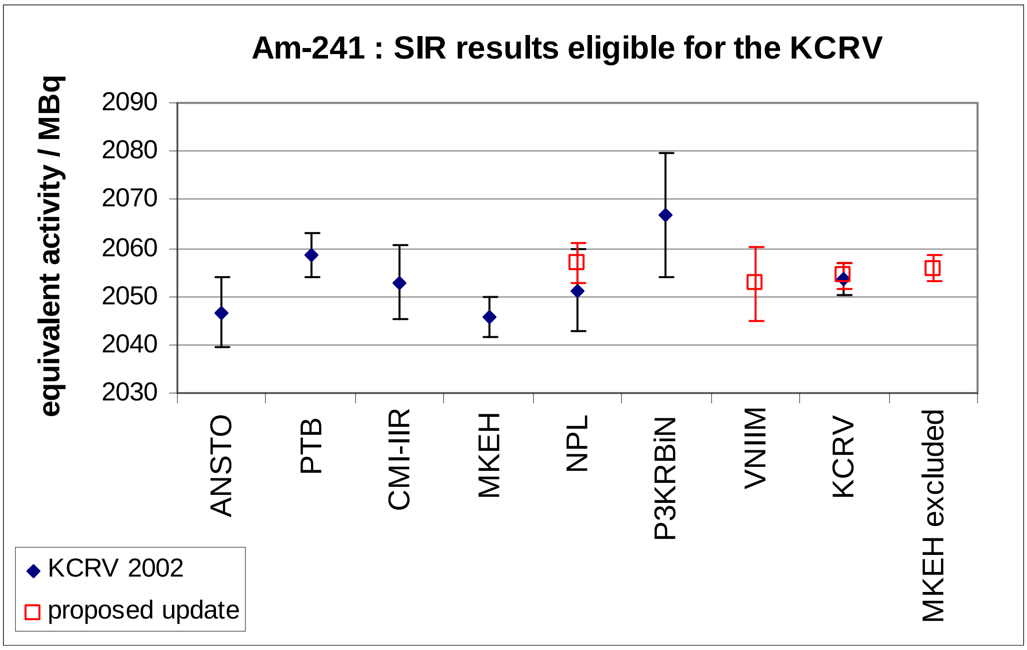

Figure 3. ^{241}Am SIR results eligible for the KCRV. Uncertainties shown are at $k = 1$.