Ionizing Radiation

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Comité consultatif des rayonnements ionisants

(CCRI)
Summary

• CCRI activities from 1999 to 2003
  – Comparisons and results that contribute to the MRA - KCDB
  – Recommendations
• Highlights in ionizing radiation metrology
• Support for world wide uniformity of measurement
C.C. for Ionizing Radiation

- Section I  $x$- and $\gamma$-rays and electrons
  - dosimetry standards and measurement methods
- Section II  measurement of radionuclides
  - measurement methods and uncertainties
- Section III  neutron measurements
  - standards and measurement methods
- CCRI, meets to harmonize procedures and recommendations
SI Derived Units for Ionizing Radiation

- activity (referred to a radionuclide)
  becquerel Bq (s⁻¹)

- absorbed dose and kerma
  gray Gy J/kg (m²⋅s⁻²)

- dose equivalent
  sievert Sv J/kg (m²⋅s⁻²)
CCRI activities from 1999 to 2003

• Comparisons with results that contribute to the MRA - KCDB, 138 for the three sections
• Recommendations
Comparisons and results that contribute to the MRA - KCDB

Section I

• 19 dosimetry comparisons registered
• 6 BIPM ongoing; 1 summary published in the KCDB
• 8 comparisons in progress; 3 completed
• 5 RMO supplementary comparisons
• KCRVs from the BIPM standards
Setting up a standard for low-energy x-ray comparison

BIPM standard on the left

Transfer standard on the right
Graph of degrees of equivalence with the KCRV for the 10 kV radiation quality (as it appears in Appendix B of the MRA)

The KCRV is the BIPM value.
Absorbed dose to water

- Transfer standard in the water phantom set in the $^{60}$Co beam at the BIPM
Graph of the degrees of equivalence with the KCRV

The KCRV is the BIPM value
Comparisons and results that contribute to the MRA - KCDB

Section II

- 87 radionuclide comparisons registered
- 45 published in the KCDB + 4 updates
- KCRVs from the International Reference System for activity measurements (SIR)
- 7 CCRI(II) comparisons in progress
  - 5 new comparisons: Am-241, Mn-54, Kr-85, Y-90, Zn-65
KEY COMPARISON

BIPM comparison BIPM.RI(II)-K1.Co-60 of the activity measurements of the radionuclide $^{60}$Co

G Ratel and C Michotte
Bureau International des Poids et Mesures, Pavillon de Breteuil, 92312 Sèvres cedex, France

Abstract. Since 1976, 20 national metrology institutes, the BIPM and two other laboratories have submitted 58 samples of known activity of $^{60}$Co to the International Reference System (SIR) for activity comparison at the Bureau International des Poids et Mesures. The activities ranged from about 0.1 MBq to 100 MBq. The degrees of equivalence between each equivalent activity measured in the SIR and the key comparison reference value (KCRV) have been calculated and the results are given in the form of a matrix. A graphical presentation is also given.

Main text. To reach the main text of this paper, click on Final Report. Note that this text is that which appears in Appendix B of the BIPM key comparison database www.bipm.org/kcdb.

Copied from the IoP Metrologia web site
The international reference system for radionuclide activity - SIR
Graph of degrees of equivalence with the KCRV for $^{60}$Co activity in the BIPM ongoing key comparison

KCRV is the mean SIR value using primary measurements at the NMIs
CCRI(II) key comparisons

absolute activity measurements of the same solution

proportional counter (PC)

pressurized PC
Graph of equivalence with the KCRV for $^{137}\text{Cs}$ activity

BIPM.RI(II)-K1.Cs-137 and 1982 CCRI(II)-K2.Cs-137

Degrees of equivalence for equivalent activity of $^{137}\text{Cs}$

SIR results

CCRI(II) results

$D_i = \frac{(x_i - x_R)}{\text{MBq}}$
Comparisons and results that contribute to the MRA - KCDB

Section III

• 24 neutron comparisons registered
• 19 published for provisional equivalence
• 4 reports in progress
  – KCRVs from a comparison mean
• 1 comparison planned
neutron dosimetry

low-scatter area at the NPL

$^{252}$Cf neutron source at the PTB

$D_2O$ moderating sphere
Graph of degrees of equivalence with the KCRV for neutron emission rates

1980 comparison approved for provisional equivalence

BIPM.RI(III)-K9.Cf-252

Degrees of equivalence for neutron emission rates

\[ D_i = \frac{(x_i - \bar{x})}{(10^4 \text{s}^{-1})} \]

KCRV from the comparison mean
CCRI activities from 1999 to 2003

– Comparisons and results that contribute to the MRA - KCDB

– Recommendations
CCRI recommendations

• To the NMIs
  – standards for dosimetry
  – radioactivity measurement and the SIR

• To the CIPM
  – international transport of standards
  – SI brochure definitions of quantities and units
  – special issues of *Metrologia*
  – CCRI section membership
Membership of CCRI Sections

• Criteria for recommendation to the CIPM, following an application from an NMI
  – national standards
    • NMIs or designated institutes
  – publications to demonstrate present activities
    • identified on the CCRI web page
  – participation in key comparisons
    • results in the KCDB
Highlights in ionizing radiation metrology

- Recent achievements
- Current collaborative ventures
- Future challenges
Recent achievements

- agreement on air kerma corrections using Monte Carlo simulation
- agreement on the procedures for determining the KCRVs
- agreement on duration of validity of comparison results in the KCDB
- agreement on minimum uncertainties for different measurement methods leading to results in the KCDB
- submission of 935 CMCs by NMIs
Progress with Calibration and Measurement Capabilities (CMCs)

- Dosimetry CMCs for SADCMET, COOMET and the IAEA
- Activity CMCs for SADCMET and 11 NMIs in EUROMET
- RMOs IR-WG: APMP, COOMET, EUROMET, SADCMET and SIM met recently to resolve some outstanding issues
  - more than 1000 CMCs in progress
A typical single CMC for activity

South Africa, CSIR-NML
(Council for Scientific and Industrial Research - National Metrology Laboratory

Complete CMCs in Ionizing Radiation for South Africa (.pdf file)

Activity. Single radionuclide, solution, 2.0E+05 Bq to 4.0E+07 Bq

Relative expanded uncertainty ($k = 2$) in %: 1

High pressure well type ionization chamber, balance

**Radionuclide: Co-60**, ampoule: 3.6 mL

Reference standard: Primary standard solution of Co-60

Source of traceability: CSIR-NML

Internal NMI service identifier: SAD-RAD-NML-2015

*Copied from Appendix C of the MRA*
Current collaborative ventures

• Working Groups study specific issues, promote discussions and report their findings to the CCRI sections

• exchange of information and ideas during the CCRI meetings fosters new projects and collaborations between the NMIs and international organizations
CCRI Working groups on:

• key comparison data KCWG(I), KCWG(III)
• physical constants SPWG(I)
• standard ionization chamber project SIWG(II)
• radionuclide groupings KCWG(II)
• extending the SIR to beta emitters ESWG(II)
• measurement uncertainties UCWG(II)
• high-efficiency activity detection - Monograph
• radionuclide data - Monograph
• the operation of the SIR - Monograph
• the preparation of radionuclide sources - Monograph
Some current collaborations with the BIPM

- activity investigations (BNM-LNHB)
- SIR efficiency curve project (NPL)
- calculation of dosimetry corrections (IRD)
- digital coincidence counting (ANSTO+NPL)
- dosimetry for mammography (NIST)
- recombination corrections (CSIR-NML)
Future challenges

• electron dosimetry
• synchrotron radiation
• digital detection methods
• activity comparisons by internet
• brachytherapy dosimetry
prostate cancer brachytherapy

- $^{192}$Ir seeds
- high dose rate
- computer controlled localization
  but this is a
- dosimetry challenge
Proposals for international cooperation through research fellows

• Brachytherapy dosimetry
  – to devise and establish an international primary standard at the BIPM for brachytherapy source dosimetry comparisons

• Absolute activity
  – to establish a NaI(Tl) well-type counter as a primary counting method at the BIPM
Support for world-wide uniformity of measurements

• close collaboration between the BIPM, the NMIs and international organizations e.g. ICRU, IAEA, IOMP, IRMM

• dissemination of robust and continuing comparisons and calibrations of standards
Support for uniformity of measurements worldwide

- BIPM ongoing key comparisons
  - stable dosimetry standards, ~ 40 y
  - SIR for activity measurements, ~ 30 y
- CCRI and RMO key comparisons
- BIPM and NMI calibrations
- BIPM collaboration with the IAEA and the IRMM
  - in disseminating reference standards
Uniformity in radiotherapy dosimetry

- support for the IAEA thermoluminescent dosimetry service in radiotherapy
Uniformity in international clinical trials

- comparison of radionuclide activity standards used for example in a lung perfusion and ventilation comparison
Uniformity in radionuclide reference materials

- activity comparisons supporting reference materials used for example in the assessment of activity in food
Summary

• the CCRI and its three sections are very active and influential
• there is productive collaboration between the NMIs, the BIPM and the international organization members
• the CCRI recognizes the work and appreciates the strong support of the BIPM IR section
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Additional information

- Visits to the BIPM laboratories
- BIPM web site www.bipm.org
- CIPM President’s Report, 22nd CGPM
- Reports of Presidents of Consultative Committees, 22nd CGPM
- Proceedings of the CCRI, see web site
- Report of the Director of the BIPM, 2003
Thank-you for your kind attention and patience
CCRI Section I Members

- ARPANSA, Australia
- BEV, Austria
- BNM-LNHB, France
- CIEMAT, Spain
- ENEA, Italy
- GUM, Poland
- ICRU
- NIM, China
- NIST, USA
- NMi-VSL, Netherlands
- NMIJ, Japan
- NPL, UK
- NRC, Canada
- OMH, Hungary
- PTB, Germany
- VNIIM, Russian Federation

Official observers
- CSIR-NML, South Africa
- IAEA
- LNMRI/IRD, Brazil
- IOMP
- SRPI, Sweden
- IRPA
CCRI Section II Members

- ANSTO, Australia
- BNM-LNHB, France
- CIEMAT, Spain
- CSIR-NML, South Africa
- ENEA, Italy
- IRA, Switzerland
- IRMM, Geel
- KRISS, Republic of Korea
- NIM, China
- NIST, USA
- NMIJ, Japan
- NPL, UK
- NRC, Canada
- OMH, Hungary
- PTB, Germany
- RC, Poland
- VNIIM, Russian Federation

Official observers

- CMI, Czech Republic
- LNMI/IRD, Brazil
- NMi-VSL, Netherlands
- ICRU
- IOMP
- IRPA
CCRI Section III Members

- BNM-LNHB, France  NIST, USA
- IRI/TNO, Netherlands  NMIJ, Japan
- IRMM, Geel  NPL, UK
- LNMRI/IRD, Brazil  PTB, Germany
- NIM, China  VNIIM, Russian Federation

Official observers

CIAE, China  IAEA
          ICRU