Bureau International des Poids et Mesures

Consultative Committee for Ionizing Radiation (CCRI)

16th Meeting (June 1999)

Note on the use of the English text

To make its work more widely accessible the Comité International des Poids et Mesures publishes an English version of its reports.

Readers should note that the official record is always that of the French text. This must be used when an authoritative reference is required or when there is doubt about the interpretation of the text.

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THE BIPM AND THE METRE CONVENTION

The Bureau International des Poids et Mesures (BIPM) was set up by the Metre Convention signed in Paris on 20 May 1875 by seventeen States during the final session of the diplomatic Conference of the Metre. This Convention was amended in 1921.

The BIPM has its headquarters near Paris, in the grounds (43 520 m^2) of the Pavillon de Breteuil (Parc de Saint-Cloud) placed at its disposal by the French Government; its upkeep is financed jointly by the Member States of the Metre Convention.

The task of the BIPM is to ensure worldwide unification of physical measurements; its function is thus to:

- establish fundamental standards and scales for the measurement of the principal physical quantities and maintain the international prototypes;
- carry out comparisons of national and international standards;
- ensure the coordination of corresponding measurement techniques;
- carry out and coordinate measurements of the fundamental physical constants relevant to these activities.

The BIPM operates under the exclusive supervision of the Comité International des Poids et Mesures (CIPM) which itself comes under the authority of the Conférence Générale des Poids et Mesures (CGPM) and reports to it on the work accomplished by the BIPM.

Delegates from all Member States of the Metre Convention attend the General Conference which, at present, meets every four years. The function of these meetings is to:

- discuss and initiate the arrangements required to ensure the propagation and improvement of the International System of Units (SI), which is the modern form of the metric system;
- confirm the results of new fundamental metrological determinations and various scientific resolutions of international scope;
- take all major decisions concerning the finance, organization and development of the BIPM.

The CIPM has eighteen members each from a different State: at present, it meets every year. The officers of this committee present an annual report on

the administrative and financial position of the BIPM to the Governments of the Member States of the Metre Convention. The principal task of the CIPM is to ensure worldwide uniformity in units of measurement. It does this by direct action or by submitting proposals to the CGPM.

The activities of the BIPM, which in the beginning were limited to measurements of length and mass, and to metrological studies in relation to these quantities, have been extended to standards of measurement of electricity (1927), photometry and radiometry (1937), ionizing radiation (1960) and to time scales (1988). To this end the original laboratories, built in 1876-1878, were enlarged in 1929; new buildings were constructed in 1963-1964 for the ionizing radiation laboratories and in 1984 for the laser work. In 1988 a new building for a library and offices was opened.

Some forty-five physicists and technicians work in the BIPM laboratories. They mainly conduct metrological research, international comparisons of realizations of units and calibrations of standards. An annual report, published in the *Procès-Verbaux des Séances du Comité International des Poids et Mesures*, gives details of the work in progress.

Following the extension of the work entrusted to the BIPM in 1927, the CIPM has set up bodies, known as Consultative Committees, whose function is to provide it with information on matters that it refers to them for study and advice. These Consultative Committees, which may form temporary or permanent working groups to study special topics, are responsible for coordinating the international work carried out in their respective fields and for proposing recommendations to the CIPM concerning units.

The Consultative Committees have common regulations (*BIPM Proc.-Verb. Com. Int. Poids et Mesures*, 1963, **31**, 97). They meet at irregular intervals. The president of each Consultative Committee is designated by the CIPM and is normally a member of the CIPM. The members of the Consultative Committees are metrology laboratories and specialized institutes, agreed by the CIPM, which send delegates of their choice. In addition, there are individual members appointed by the CIPM, and a representative of the BIPM (Criteria for membership of Consultative Committees, *BIPM Proc.-Verb. Com. Int. Poids et Mesures*, 1996, **64**, 124). At present, there are ten such committees:

1 The Consultative Committee for Electricity and Magnetism (CCEM), new name given in 1997 to the Consultative Committee for Electricity (CCE) set up in 1927;

2 The Consultative Committee for Photometry and Radiometry (CCPR), new name given in 1971 to the Consultative Committee for Photometry (CCP) set up in 1933 (between 1930 and 1933 the CCE dealt with matters concerning photometry);

3 The Consultative Committee for Thermometry (CCT), set up in 1937;

4 The Consultative Committee for Length (CCL), new name given in 1997 to the Consultative Committee for the Definition of the Metre (CCDM), set up in 1952;

5 The Consultative Committee for Time and Frequency (CCTF), new name given in 1997 to the Consultative Committee for the Definition of the Second (CCDS) set up in 1956;

6 The Consultative Committee for Ionizing Radiation (CCRI), new name given in 1997 to the Consultative Committee for Standards of Ionizing Radiation (CCEMRI) set up in 1958 (in 1969 this committee established four sections: Section I (X- and γ-rays, electrons), Section II (Measurement of radionuclides), Section III (Neutron measurements), Section IV (α-energy standards); in 1975 this last section was dissolved and Section II was made responsible for its field of activity);

7 The Consultative Committee for Units (CCU), set up in 1964 (this committee replaced the "Commission for the System of Units" set up by the CIPM in 1954);

8 The Consultative Committee for Mass and Related Quantities (CCM), set up in 1980;

9 The Consultative Committee for Amount of Substance (CCQM), set up in 1993;

10 The Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV), set up in 1998.

The proceedings of the General Conference, the CIPM and the Consultative Committees are published by the BIPM in the following series:

- *Comptes Rendus des Séances de la Conférence Générale des Poids et Mesures;*
- *Procès-Verbaux des Séances du Comité International des Poids et Mesures;*
- *Reports of Meetings of Consultative Committees.*

The BIPM also publishes monographs on special metrological subjects and, under the title *Le Système International d'Unités (SI)*, a brochure, periodically updated, in which are collected all the decisions and recommendations concerning units.

The collection of the *Travaux et Mémoires du Bureau International des Poids et Mesures* (22 volumes published between 1881 and 1966) and the *Recueil de Travaux du Bureau International des Poids et Mesures* (11 volumes published between 1966 and 1988) ceased by a decision of the CIPM.

The scientific work of the BIPM is published in the open scientific literature and an annual list of publications appears in the *Procès-Verbaux* of the CIPM.

Since 1965 *Metrologia*, an international journal published under the auspices of the CIPM, has printed articles dealing with scientific metrology, improvements in methods of measurement, work on standards and units, as well as reports concerning the activities, decisions and recommendations of the various bodies created under the Metre Convention.

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR IONIZING RADIATION

as of 2 June 1999

President

G. Moscati, Member of the Comité International des Poids et Mesures; Instituto de Fisica, Universidade de São Paulo, São Paulo.

Executive secretary

P. Allisy-Roberts, Bureau International des Poids et Mesures [BIPM], Sèvres.

Members

The Chairman of Section I.

The Chairman of Section II.

The Chairman of Section III.

The Director of the Bureau International des Poids et Mesures [BIPM], Sèvres.

Section I (X- and γ-rays, electrons)

Chairman

K. Hohlfeld, Physikalisch-Technische Bundesanstalt, Braunschweig.

Members

Australian Radiation Protection and Nuclear Safety Agency [ARPANSA], Victoria.

Bundesamt für Eich- und Vermessungswesen [BEV], Vienna.

Bureau National de Métrologie, Laboratoire National Henri Becquerel [BNM-LNHB], Gif-sur-Yvette.

Central Office of Measures/Glówny Urzad Miar [GUM], Warszawa.

D.I. Mendeleyev Institute for Metrology [VNIIM], St Petersburg.

Electrotechnical Laboratory [ETL], Tsukuba.

Ente per le Nuove Technologie, l'Energia e l'Ambiente, Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti [ENEA-INMRI], Roma.

International Commission on Radiation Units and Measurements [ICRU].

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Office of Measures/Országos Mérésügyi Hivatal [OMH], Budapest.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Nederlands Meetinstituut, Van Swinden Laboratorium [NMi-VSL], AR Delft.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Swedish Radiation Protection Institute/Statens Stralskyddsinstitut [SRPI], Stockholm.

A. Brosed, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas [CIEMAT], Madrid.

The Director of the Bureau International des Poids et Mesures [BIPM], Sèvres.

Observers

International Atomic Energy Agency [IAEA], Vienna.

International Organization for Medical Physics [IOMP].

International Radioprotection Association [IRPA].

Laboratório Nacional de Metrologia das Radiações Ionizantes [LNMRI], Rio de Janeiro.

Section II (Measurement of radionuclides)

Chairman

B.R.S. Simpson, National Accelerator Centre, Faure.

Members

Australian Nuclear Science and Technology Organisation [ANSTO], Menai.

Bureau National de Métrologie, Laboratoire National Henri Becquerel [BNM-LNHB], Gif-sur-Yvette.

Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas [CIEMAT], Madrid.

D.I. Mendeleyev Institute for Metrology [VNIIM], St Petersburg.

Electrotechnical Laboratory [ETL], Tsukuba.

Institute for Reference Materials and Measurements [IRMM], Geel.

Korea Research Institute of Standards and Science [KRISS], Taejon.

National Accelerator Centre [NAC], Faure.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Office of Measures/Országos Mérésügyi Hivatal [OMH], Budapest.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Radioisotope Centre Polatom [RC], Swierk.

J.-J. Gostely, Institut de Radiophysique Appliquée [IRA-OFMET], Lausanne.

G. Winkler, Institut für Radiumforschung und Kernphysik [IRK], Vienna.

The Director of the Bureau International des Poids et Mesures [BIPM].

Observers

Czech Metrology Institute/Český Metrologický Institut [CMI], Praha.

Ente per le Nuove Technologie, l'Energia e l'Ambiente, Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti [ENEA-INMRI], Roma.

International Commission on Radiation Units and Measurements [ICRU].

International Organization for Medical Physics [IOMP].

International Radioprotection Association [IRPA].

Nederlands Meetinstituut, Van Swinden Laboratorium [NMi-VSL], AR Delft.

Section III (Neutron measurements)

Chairman

V.E. Lewis, National Physical Laboratory, Teddington.

Members

Bureau National de Métrologie, Laboratoire National Henri Becquerel [BNM-LNHB], Gif-sur-Yvette.

D.I. Mendeleyev Institute for Metrology [VNIIM], St Petersburg.

Electrotechnical Laboratory [ETL], Tsukuba.

Institute for Reference Materials and Measurements [IRMM], Geel.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Physical Laboratory [NPL], Teddington.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

J.J. Broerse [IRI/TNO], Rijswijk.

The Director of the Bureau International des Poids et Mesures [BIPM].

Observers

Chinese Institute of Atomic Energy [CIAE], Beijing.

International Atomic Energy Agency [IAEA].

International Commission on Radiation Units and Measurements [ICRU].

Consultative Committee for Ionizing Radiation

Report of the 16th Meeting
(2 June 1999)
to the Comité International des Poids et Mesures

Agenda

1 Opening of the meeting.
2 Report of fifteenth meeting of the CCEMRI.
3 Conclusions of the meetings of the three Sections of the CCRI:
  3.1 Section I: x- and γ-rays, electrons;
  3.2 Section II: measurement of radionuclides;
  3.3 Section III: neutron measurements.
4 Discussion of points of common interest:
  4.1 MRA matters of related interest;
  4.2 Work of the BIPM;
  4.3 Report to the General Conference;
  4.4 Membership of Sections.
5 Date of next meetings.
6 Concluding remarks.

Abstract

The Consultative Committee for Ionizing Radiation (CCRI) held its sixteenth meeting (the first with its new title) at the BIPM on 2 June 1999. The new procedure involved a short presentation of the main conclusions from each of the CCRI Section meetings, followed by a discussion of points of common interest. The major items were the implementation of the Mutual Recognition Arrangement (MRA) through relevant key comparisons, the report to the General Conference and future membership of the CCRI and its Sections.

1 OPENING OF THE MEETING

The sixteenth meeting of the Consultative Committee for Ionizing Radiation (CCRI) was held at the Pavillon de Breteuil, in Sèvres, on 2 June 1999.

The following members were present: K. Hohlfeld (Chairman of CCRI Section I), V. Lewis (Chairman of CCRI Section III), G. Moscati (President of the CCRI), T.J. Quinn (Director of the BIPM) and M. Woods (Rapporteur of CCRI Section II).

Also in attendance: P. Allisy-Roberts (Executive Secretary of the CCRI).

The President, Prof. Moscati, opened the meeting by explaining that it was the first meeting under the new name of CCRI rather than CCEMRI (Consultative Committee for Standards of Ionizing Radiation), and that the members and method of working were also new. The members of the CCRI are now simply the President, the Chairmen of the three Sections and the Director of the BIPM. As Dr Simpson, President of Section II, was unable to attend, Mr Woods, the rapporteur for this Section, was invited to present the conclusions of the Section II meeting.

2 REPORT OF FIFTEENTH MEETING OF THE CCEMRI

The report of the fifteenth meeting of the CCEMRI was short and had already been discussed in the Sections. The President regretted the lack of "external input" to the new CCRI but the Director of the BIPM explained that this was now in accordance with the other Consultative Committees, adding that the future needs in ionizing radiation metrology as required by the end users was a question for the national metrology institutes (NMIs) to consider and pass on to the CCRI as appropriate. Mr Woods pointed out that the ICRM is one link between NMIs and the users. There are also representatives invited from the international organizations, the IAEA, the ICRU, the IOMP and the IRPA who are able to feed some needs into the CCRI. The President asked each Section to ensure that it considered future metrological requirements at each Section meeting.

3 CONCLUSIONS OF THE MEETINGS OF THE THREE SECTIONS OF THE CCRI

The Chairman encouraged the BIPM to prepare for the new millennium in terms of the changes to the work programme anticipated with the acceptance of the MRA. He then asked the Section Chairmen to report on the decisions made in each Section which need to be reported to the CIPM and to the General Conference.

3.1 Section I: x- and γ-rays, electrons (Chairman: K. Hohlfeld)

Prof. Hohlfeld referred to the four BIPM key comparisons and mentioned that in each case the BIPM value would be used as the reference value because the BIPM standards are more stable than the differences between the standards of the NMIs; that bilateral comparisons may be used as a check for equivalence and that normally each NMI would compare its standards with the BIPM at least every ten years. He mentioned the various supplementary comparisons that were in hand and that the problem of defining radiation quality for high-energy radiation needed to be resolved. He spoke of the working group which had been set up to respond to the problems identified with correction factors relating to air kerma standards, and of the schedule for future comparisons.

Prof. Moscati expressed concern that as the CCRI meets only every two years, an NMI may have to wait two years before its comparison results could be added to the BIPM key comparison database (KCDB). Following discussion, it was agreed that approval for ongoing BIPM comparisons could be obtained by correspondence.

3.2 Section II: measurement of radionuclides (Chairman: M. Woods)

Mr Woods mentioned the two recent activity comparisons completed by Section II. The problems identified in the ^{204}Tl comparison were to be investigated by a working group. He reported that the ^{192}Ir comparison results would not be included in the KCDB but that a member of Section II is to document all the difficulties encountered in measuring this radionuclide activity and that this paper would be distributed prior to a future comparison.

New CCRI(II) key comparisons were in progress for ^{152}Eu, ^{89}Sr and ^{238}Pu and the two regional comparisons which had been identified (^{59}Fe in the APMP and ^{237}Np in the EUROMET) would submit ampoules to the International

Reference System (SIR) to ensure a link to the international standards. It was noted that regional comparisons should be identified in advance to the CCRI(II).

Mr Woods reported that the CCRI(II) comparisons and the SIR results would be used as the basis for degrees of equivalence between NMIs; the unweighted means would be used for the reference values as the uncertainty budgets were not yet consistent. It was hoped to have a monograph of all the SIR data sets by the end of 1999. The data would be revisited every two years to include new submissions. It was indicated that some early comparisons would not be included in the KCDB, even for provisional equivalence.

It was remarked that the joint project between the IRMM and the NPL to design and construct an ionization chamber to be used by NMIs was on schedule.

Regarding the extension of the SIR to include beta emitters, a new coordinator (Dr Los Arcos) had been nominated to produce a monograph with recipes for liquid scintillation measurements and it was intimated that Dr De Felice would produce a paper describing an alternative method using liquid scintillation. Attention was brought to the fact that the new location for the SIR would have a humidity- and temperature-controlled environment.

Mr Woods reported the earlier deadlines which had been agreed for submissions to the CCRI meetings, so that papers would be received at least two weeks beforehand.

3.3 **Section III: neutron measurements** (Chairman: V. Lewis)

Dr Lewis reported that Section III had decided to keep all previous comparison results as they represented a large investment by the NMIs and covered many different aspects of neutron metrology. As there was no longer an international facility at the BIPM, Section III had to consider circulating transfer instruments to undertake some key comparisons.

Regarding the KCDB, Dr Lewis described the calculation of degrees of equivalence as not being simple; for example, one key comparison involves nine separate neutron fields, includes only five participants and has generated uncertainty budgets that are not consistent. Decisions on the reference value and degrees of equivalence would be pursued by correspondence. It was pointed out that better information on uncertainty budgets, as envisaged, for example, in the Guidelines for BIPM key comparisons to be produced for the MRA, should help NMIs to provide more consistent uncertainties.

Section III favoured the ten-year repetition rate for key comparisons and the next key comparison would be hosted by the PTB, with all participants making their measurements within two to three weeks. Another comparison, to measure neutron emission rates, would be made by circulating an Am-Be source to ten participating NMIs. It was hoped to start this within six months although there were difficulties to overcome regarding the circulation of radioactive material. This comparison would parallel a EUROMET comparison and the link would be made through the NPL and the PTB.

4 DISCUSSION OF POINTS OF COMMON INTEREST

4.1 MRA matters of related interest

Dr Quinn reported that another Consultative Committee had decided to eliminate the problem of unrealistically low uncertainties for measurements, by identifying a "state-of-the-art" uncertainty budget as the lowest acceptable value to be used when deriving degrees of equivalence. This could be a useful precedent for the CCRI to follow.

Dr Quinn had written to the IAEA and the IRMM inviting them to participate in the MRA.

4.2 Work of the BIPM

Favourable comments were made regarding the work of the BIPM Ionizing Radiation section, especially in view of the workload of comparison requests resulting from the MRA.

At the upcoming CIPM meeting, Prof. Moscati agreed to highlight the problems associated with the purchase of a new ^{60}Co source.

4.3 Report to the General Conference

Prof. Moscati asked for assistance regarding the President's report for the General Conference, in particular for help with preparation of transparencies for his oral report. He needed images representing the importance of the work in the fields covered by ionizing radiation and the particular messages to be transmitted.

4.4 Membership of Sections

A general discussion on membership raised questions as to whether NMIs participating in comparisons should be invited as observers, and whether NMIs which were no longer active in the field should be invited to reconsider their membership. The Sections agreed to consider an agenda item regarding future membership.

Dr Lewis indicated that he would be resigning as Chairman of Section III and a new Chairman would need to be invited by the President prior to the next meeting. As the Chairman of Section I would also be retiring from the next meeting, the President of the CCRI agreed to invite a replacement for Prof. Hohlfeld.

5 DATE OF NEXT MEETINGS

It was proposed that the three Section meetings be held in parallel in two years' time. However, as some NMI representatives were nominated to more than one Section, and as the CCRI President, the CCRI Section Chairmen, the Executive Secretary, the Director of the BIPM and the BIPM Ionizing Radiation section staff needed to attend all three Sections, it was decided that holding the meetings in close series was more appropriate, with Section II being adjacent to the ICRM meeting. Working group meetings could perhaps be held in parallel if these were needed just before or after the Section meetings.

6 CONCLUDING REMARKS

At the end of the meeting, the President thanked the BIPM for its hospitality. It was noted that the microphone system was helpful in the Grande Salle and that the administration had been most efficient. The President also thanked the BIPM staff, the CCRI members and the rapporteurs of the three Sections.

The Sections were requested to send their reports as soon as possible to help in the preparation for the General Conference.

January 2001

Consultative Committee for Ionizing Radiation

Section I: X- and γ-rays, electrons

Report of the 14th Meeting

(26–28 May 1999)

Agenda

1 Opening of the meeting; approval of the agenda; appointment of a rapporteur.

2 Report of the fifteenth meeting of the CCEMRI.

3 Comparisons of measurements standards (x- and γ-rays):

- 3.1 BIPM comparisons and calibrations;
- 3.2 National laboratories;
- 3.3 Regional comparisons;
- 3.4 Schedule of future comparisons.

4 Key comparisons:

- 4.1 The value of *W/e* and its uncertainty;
- 4.2 The estimation of k_{att}, k_{sc}, k_{CEP} and their uncertainties;
- 4.3 Analysis of key comparisons and the role of bilateral and regional comparisons;
- 4.4 Future work.

5 Present and future work of the BIPM:

- 5.1 Changes to the measurement systems;
- 5.2 New source for the ^{60}Co unit;
- 5.3 High-energy x-ray transfer system;
- 5.4 Electron loss and photon scattering corrections for free-air chambers;
- 5.5 Experimental results on ion recombination;
- 5.6 Development of the graphite calorimeter.

6 Development and improvement of national standards for photon dosimetry:

- 6.1 Air kerma;
- 6.2 Absorbed dose to water.

7 Dissemination of $N_{D,w}$ calibration factors:

7.1 Comparison of $N_{D,w}$ and N_K;

7.2 New codes of practice.

8 Other national standards for photon dosimetry:

8.1 Standards for brachytherapy;

8.2 Standards for radiation protection;

8.3 Standards for radiation processing.

9 Development and improvement of national standards for charged particle dosimetry:

9.1 Electron beams;

9.2 Beta-ray fields;

9.3 Proton beams.

10 Status reports and additional information from member laboratories.

11 Reports from international observers:

11.1 ICRU;

11.2 IAEA.

12 Publications.

13 Other business; date of next meeting.

Abstract

Section I of the Consultative Committee for Ionizing Radiation (CCRI) held its fourteenth meeting at the Pavillon de Breteuil, Sèvres, in May 1999. The recent work of the BIPM was reviewed, in particular the results of international comparisons. A programme of future work was agreed, based on detailed discussion, particularly concerning uncertainties and the reports of member laboratories. The Director of the BIPM presented the Mutual Recognition Arrangement (MRA) being developed between the national metrology institutes (NMIs) and this provoked considerable discussion on the way forward for Section I, in terms of the BIPM key comparison database and the programme for future comparisons. Decisions were reached on key comparison reference values and the actions required to ensure that uncertainties presented by the NMIs are consistent and complete. Progress on various dosimetry standards was presented by the BIPM and the NMIs. Reports from the international observers were noted.

1 OPENING OF THE MEETING; APPROVAL OF THE AGENDA; APPOINTMENT OF A RAPPORTEUR

Dr Quinn welcomed all participants and expressed his pleasure at the number that had been able to attend.

The following were present: A.H.L. Aalbers (NMi-VSL), A. Allisy (ICRU), J.F. Boas (ARPANSA), A. Brosed (CIEMAT), B. Chauvenet (BNM-LNHB), I. Csete (OMH), K. Hohlfeld (Chairman, PTB), R.F. Laitano (ENEA-INMRI), G. Moscati (President of the CCRI), T.J. Quinn (Director of the BIPM), Z. Referowski (GUM), D.W.O. Rogers (NRC), S.M. Seltzer (NIST), P. Sharpe (NPL), N. Takata (ETL), Tian Zhongqing (NIM), N.D. Villevalde (VNIIM), J. Witzani (BEV).

Observer: P. Andreo (IAEA).

Invited: B.R.S. Simpson (NAC).

Attending all or part of the meeting: P. Giacomo (Director Emeritus of the BIPM); P. Allisy-Roberts (Executive Secretary of the CCRI), D.T. Burns, C. Michotte, G. Ratel and C. Thomas (BIPM).

Apologies were received from: L.N. Rodrigues (IRD).

Before beginning formal business, Prof. Hohlfeld reported to the meeting the recent death of Dr H.O. Wyckoff, who had long associations with the CCEMRI through the NIST and the ICRU, and was known personally by many of those present. A minute's silence was respected.

The Chairman then reiterated the Director's welcome and invited the members around the table to introduce themselves. After this, he explained the purpose and importance of the meeting in advancing metrology in radiation dosimetry in a consistent and coherent manner internationally. In the future this would become even more crucial with the MRA being promoted by the CIPM as this would lead to the identification of degrees of equivalence between the national metrology institutes.

The agenda was very comprehensive and he encouraged everyone to look forward to three days of full and constructive discussion with some definitive recommendations for the future work of Section I.

Dr Sharpe was appointed rapporteur.

Dr Rogers asked that a discussion on beam quality specifiers be included in the agenda. It was agreed that this would be taken under Item 5.3. At an appropriate point in the agenda (Item 4), Dr Quinn would present an introduction to the MRA and what this entailed in terms of key comparisons.

2 REPORT OF THE FIFTEENTH MEETING OF THE CCEMRI

The Chairman gave a brief report of the fifteenth meeting of the CCEMRI, held in July 1997. A number of significant changes in membership and operation of the Committee had been approved, including a change of name to Consultative Committee for Ionizing Radiation (CCRI) which would now be comprised of the President, Section Chairmen and the Director of the BIPM, with the Executive Secretary. The external members on the former CCEMRI were no longer members of the CCRI. To improve communication between the Sections of the CCRI, a decision had been taken that the President and Section Chairmen be invited to attend all Section meetings and consequently Dr Simpson (Chairman of Section II) was present at this Section I meeting. A short meeting of the CCRI would be held immediately after the three Section meetings in order to agree on common conclusions.

It was reported that the ENEA (Italy) and BEV (Austria) were now members of the CCRI(I) and that the IAEA, IOMP, IRPA and the LNMRI had been given observer status.

Dr Rogers commented that it would be an advantage to have more meaningful names for the Sections than the current I, II and III. It was pointed out that the existing, official names for each Section, when used in full, already include the appropriate descriptors. No suggestions for change were forthcoming from the meeting.

3 COMPARISONS OF MEASUREMENT STANDARDS (X- AND γ-RAYS)

3.1 BIPM comparisons and calibrations

Dr Allisy-Roberts and Dr Burns presented a summary of the current status of dosimetry comparisons and calibrations (CCRI(I)/99-1). The number of comparisons with the BIPM had increased considerably recently, mainly due to the need to update values for inclusion in the BIPM key comparison database. Since the last meeting of CCRI(I), twenty-six comparisons and thirty-one calibrations had been carried out. Dr Allisy-Roberts pointed out that a number of comparisons in CCRI(I)/99-1 were listed as provisional, despite having been carried out some time ago and stressed the need for comparisons to be finalized and the results published as rapidly as possible. The meeting considered the results as presented in CCRI(I)/99-1, and a number of specific items were noted for revision. Some concern was expressed that differences observed in bilateral comparisons were not always reflected when comparing the two NMIs through the corresponding BIPM comparison results. This was particularly apparent with respect to the NRC/NIST ^{60}Co absorbed dose to water comparisons, and was difficult to explain in terms of the magnitudes and known correlations of the relevant components of uncertainty.

3.2 National laboratories

In addition to the BIPM comparisons, the following comparisons were mentioned as having been carried out since the last meeting of the CCRI(I). In many cases the results can be found in the respective laboratory reports submitted to the meeting:

- NMi, PTB and NPL: low-energy x-ray air kerma (mammographic qualities);
- ARPANSA and NRC: ^{60}Co air kerma;
- ARPANSA and NPL: ^{60}Co and high-energy x-ray absorbed dose to water;
- ENEA and NIST: low-energy x-ray and ^{60}Co air kerma;
- NIST, NPL and PTB: low-energy x-ray air kerma.

3.3 Regional comparisons

Dr Allisy-Roberts reported that a summary of COMECON comparisons of air kerma standards in x- and γ-radiation fields, including the equivalent BIPM comparisons, had recently been published as *Rapport BIPM*-98/8.

3.4 Schedule of future comparisons

The discussion on future comparisons was taken later under Item 4.4.

4 KEY COMPARISONS

At this point Dr Quinn gave a brief introduction to the Mutual Recognition Arrangement of National Measurement Standards and of Calibration and Measurement Certificates. It had been initialled in draft form by the directors of NMIs in 1998 and it was planned that formal signature would take place during the 21st General Conference in October 1999. An essential component of the MRA is the establishment of the degree of equivalence of national measurement standards through a series of "key comparisons". The organization of these comparisons will be the responsibility of the Consultative Committees (CCs). It is intended that the results will be available publicly in the form of the on-line BIPM key comparison database, which will provide the "degrees of equivalence" between standards. The CC "key comparisons" will normally only involve CC members and will establish a "reference value" related to the relevant SI unit, based on an agreed method of combining the results. Further comparisons involving regional metrology organizations will extend the degrees of equivalence to other laboratories. Dr Quinn indicated that it may be possible for the IAEA to have a special status, thereby connecting its associated network of secondary standard dosimetry laboratories to the international system.

4.1 The value of *W/e* and its uncertainty

Dr Rogers presented data from the NRC on measured electron stopping powers (CCRI(I)/99-24). In general, there was satisfactory agreement with calculated (ICRU 37) values, the largest differences occurring with aluminium (0.7 % between 20 MeV and 30 MeV). The data for graphite (5 MeV to 30 MeV) clearly indicated that the grain density, not the bulk density, should be used in calculations of the density effect. The results imply a difference of 0.3 % at ^{60}Co between calculations using the two densities. The results also have implications for the value of *W/e* as a result of the close interrelation between *W/e* and stopping power ratios.

Dr Allisy-Roberts proposed that, for the purposes of analyzing key comparison data, a common value of 0.11 % should be used by all the NMIs for the uncertainty of the product $W/e \cdot s_{c,a}$. This was agreed by the meeting.

4.2 The estimation of k_{att}, k_{sc}, k_{CEP} and their uncertainties

Dr Allisy-Roberts briefly outlined a paper by Mme Boutillon (CCRI(I)/99-3) in which experimental and calculated values for k_{wall} had been compared for a number of primary standards. A statistical analysis had been made based on the results of comparisons between NMIs and the BIPM, using both experimental and calculated values for k_{wall}. For ^{60}Co air kerma standards there was clear evidence of better agreement between cylindrical and "pancake" chamber types if experimental rather than calculated values were used. The situation for ^{137}Cs air kerma standards appeared more complicated, exhibiting a significant difference (0.7 %) between cylindrical and "pancake" chamber types when experimental k_{wall} factors were used. Calculated k_{wall} factors for ^{137}Cs were not yet available.

Dr Rogers presented new results from the NRC (CCRI(I)/99-26) which compared experimental and calculated wall and axial non-uniformity corrections factors for the chamber designs used by the BIPM and a number of NMIs. Calculations had been made for both ^{60}Co and ^{137}Cs radiation. Agreement between experimental and calculated data was satisfactory for added wall thickness (better than 0.2 % in most cases), which gave confidence that the method of calculation was valid. There were, however, significant differences between correction factors calculated by Monte Carlo methods and those obtained by extrapolation of experimental data to zero

wall thickness. If existing comparison results between NMIs and the BIPM are adjusted for the NRC calculated correction factors, the effect is to increase the mean air-kerma rate for ^{60}Co by 0.8 %. In addition, the mean ratio NMI/BIPM increases from 1.001 to 1.005. Some calculations had been carried out for ^{137}Cs and these indicated a similar 0.8 % change to the mean air kerma rate, although the scatter in the data is larger than that for ^{60}Co.

The issue of correction factors for air-kerma cavity standards was discussed in detail and it became apparent that several NMIs were now actively re-evaluating the corrections for their standards. In view of the imminent publication of the equivalence database (Appendix B of the MRA), it was agreed that steps needed to be taken to reconcile the various approaches being adopted. The following actions were approved:

a) Before publishing the equivalence database, BIPM will ask NMIs to review their ^{60}Co air kerma uncertainties and consider whether an increase in their quoted uncertainty is necessary in the light of the recent Monte Carlo calculations.

b) The method of determining correction factors (Monte Carlo, experimental or both) will be identified in the equivalence database for ^{60}Co air-kerma. Also a statement will be added on the implication of differences between the two methods on the uncertainty estimates.

c) A working group will be established to study and report back to the CCRI(I) in eighteen months on the implications of using Monte Carlo correction factors for ^{60}Co air kerma standards. Members: BNM-LPRI, NIST, NMi (Chairman), NPL, BIPM. The NRC agreed to act in the capacity as a consultant and to submit to the working group the paper that it intended to publish on this topic.

4.3 Analysis of key comparisons and the role of bilateral and regional comparisons

Since bilateral comparisons and regional comparisons were closely related to the modifications to the proposal of the Working Group on Key Comparisons [CCRI(I)/99-2] they were discussed together.

Dr Allisy-Roberts introduced document CCRI(I)/99-2, which set out a proposed method for determining the SI reference value for air kerma in ^{60}Co radiation. The document had been prepared in response to a decision of the last CCRI(I) meeting to treat air kerma in ^{60}Co radiation as a pilot for all

dosimetry key comparisons. It was hoped that the approach taken could be adapted for use with other comparisons.

After a comprehensive discussion, the following decisions were approved by the CCRI(I) in connection with the conduct of key comparisons and the establishment of the equivalence database:

a) The equivalence database will be constructed from ongoing BIPM comparisons. Bilateral comparisons between NMIs will serve as additional validation, the results of which may appear in the database, but at a lower level of visibility and with their status clearly identified.

b) Only published results will be included in the equivalence database. Equivalence will normally be based on the most recent comparison, unless exceptional circumstances justify an averaged value. Comparisons over ten years old will normally be removed from the database, unless their retention is sanctioned by the CCRI(I).

c) The BIPM value is to be used as the reference value for all dosimetry key comparisons.

d) The following comparisons were approved:

- BIPM key comparisons
  - i) air kerma ^{60}Co,
  - ii) air kerma low energy x-rays,
  - iii) air kerma medium energy x-rays,
  - iv) absorbed dose to water ^{60}Co;
- BIPM supplementary comparisons
  - i) air kerma ^{137}Cs,
  - ii) absorbed dose to graphite;
- CCRI supplementary comparisons
  - i) high dose comparison (see 8.3),
  - ii) high-energy x-ray comparison (see 5.3),
  - iii) ^{60}Co absorbed dose calibration capability comparison (see 4.4) Secretarial note: by definition, this is actually a CCRI(I) key comparison.

e) For low- and medium-energy x-ray key comparisons, all BIPM qualities should be used if possible, but this is not mandatory. Equivalence will be determined for individual qualities i.e. no averaging of results over several qualities.

f) New results (plus full uncertainty budgets) for inclusion in the equivalence database will be circulated to all CCRI(I) members for approval. Inclusion will be automatic if no objections are received within two months. Minor points of detail will be dealt with by the BIPM, but significant objections will be referred to the next CCRI(I) meeting.

g) The published equivalence database will show only current results. Old values may be available at a deeper level of interrogation.

h) To remain in the equivalence database, NMIs will normally be required to repeat key comparisons at least once every ten years. It was recognized that efficient scheduling of comparisons at the BIPM will require advance planning; a draft schedule of key comparisons for the next two years was presented and agreed in principle (CCRI(I)/99-32).

i) It was noted that regional and bilateral comparisons for inclusion in Appendix B of the MRA must be presented to the CCRI(I) in advance and follow the appropriate methodology and reference conditions in order to be linked properly to the appropriate key comparison reference value of CCRI(I).

4.4 Future work

Concern was expressed by several representatives about the quality of some recently published comparisons involving ionization chamber absorbed dose calibrations. It was agreed that the CCRI(I) should initiate a new comparison on ^{60}Co absorbed-dose calibration capabilities. Chambers will be taken from the BIPM to each of the participating laboratories for calibration, using the usual instrumentation for a laboratory calibration, in terms of absorbed dose to water in ^{60}Co radiation. The BIPM will draft a detailed protocol and coordinate the work. The comparison should be completed before the next meeting of the CCRI(I). Representatives of the following NMIs indicated that they wished to participate: ARPANSA, BEV, BNM, ENEA, NIST, NPL, NRC and PTB.

5 PRESENT AND FUTURE WORK OF THE BIPM

5.1 Changes to the measurement systems

Dr Allisy-Roberts reported that the dosimetry measurement equipment at the BIPM had been extensively upgraded with new data acquisition and parameter monitoring systems. Additional processes were now under direct computer control.

5.2 New source for the ^{60}Co unit

It was planned to install a new 170 TBq source in the ^{60}Co irradiator but progress had been slower than anticipated owing to difficulties with the transport licence for the source container. In addition, replacements for the low-energy x-ray tube and high-voltage generators were planned as the latter were becoming difficult to maintain. The safety systems for all the irradiation facilities were being upgraded.

5.3 High energy x-ray transfer system

Extensive work to test the stability of the chambers to be used for high-energy x-ray comparisons had been carried out since the last CCRI(I) meeting. Stability of the thimble chambers had been found to be very good, but results from the parallel-plate chambers were disappointing, showing changes in response of up to 0.6 %. Dr Allisy-Roberts pointed out that since precise chamber positioning was more difficult with the plane parallel chambers this may account for some of the observed variations. While further work on this project was planned, it was noted that the chambers were now ready to be taken to the PTB, the NPL and the NRC on request.

Dr Rogers raised the question of beam quality specifiers for high-energy photon beams (CCRI(I)/99-25) and suggested that %dd(10) had a number of advantages over the more commonly used TPR^{20}_{10}. There were also, however, a number of practical drawbacks to its use, for example, the need to use lead foil to reduce electron contamination. In addition, a number of standards laboratories could not produce the required 10 cm × 10 cm field at 100 cm to enable %dd(10) to be measured directly, although it had been shown that

suitable correction factors could be calculated to enable other beam sizes to be used. In the light of the increasing use of %dd(10), Dr Rogers suggested that both %dd(10) and TPR_{10}^{20} should be measured in the planned high-energy x-ray comparison.

Prof. Andreo commented that the potential advantages cited for %dd(10) were less significant in realistic clinical beams (CCRI(I)/99-31). He was also concerned at the use of lead as an electron filter and pointed out that the ICRU recommended the use of copper or brass. From a practical point of view, he felt that it was easier for users to make accurate determinations of TPR_{10}^{20} than %dd(10).

Dr Boas presented data (CCRI(I)/99-27) from comparisons made between the ARPANSA and the NPL that indicated a significant machine dependence of k_Q values for certain types of chamber when using TPR_{10}^{20} as the quality specifier. In particular, a difference in k_Q values was observed between NE 2561 and NE 2611 chambers irradiated at the ARPANSA, whereas no difference was seen between these chamber types when irradiated at the NPL. The difference appeared to originate from machine-dependent behaviour of the NE 2611 chambers.

Dr Sharpe confirmed that measurements at the NPL had shown no difference in the k_Q values for NE 2561 and NE 2611 chambers up to 19 MV when using TPR_{10}^{20} as the quality specifier. He also presented data on measured k_Q values for NE 2571 chambers, which were significantly different from those for the NE 2561 and NE 2611 chambers (CCRI(I)/99-20) as would be expected.

5.4 Electron loss and photon scattering corrections for free-air chambers

Dr Burns presented the results of an extensive set of Monte Carlo calculations of electron loss (k_e) and photon scatter (k_{sc}) corrections for parallel-plate free-air chambers (CCRI(I)/99-4). Calculations had been made for thirteen medium-energy chambers and sixteen low-energy chambers and corrections determined for each chamber at each of the BIPM reference qualities. For medium-energy chambers the new calculated values agreed with existing values within expected uncertainties, the standard deviations between calculated and existing values being 0.04 % and 0.08 % for k_e and k_{sc},

respectively. For low-energy chambers, the calculated k_e values were between 0.2 % and 0.4 % higher than existing values, in line with other evidence that the existing values may be low. Calculated k_{sc} values for the low-energy chambers were between 0.1 % and 0.2 % higher than existing values, although it was thought this may be due to the neglect of fluorescent x-ray transport in the calculations.

5.5 Experimental results on ion recombination

Dr Allisy-Roberts drew attention to the recent publication of Mme Boutillon* on the volume recombination parameter in ionization chambers which presented experimental results for free-air chambers and the effects of variations in experimental and environmental conditions. In this paper, the voltage-ratio method was used, as proposed by Mme Niatel and adopted by the BIPM, which distinguishes initial and volume recombination (not to be confused with the two-voltage method often used which gives a single estimate of the total recombination). Dr Allisy-Roberts presented some experimental results for various graphite cavity ionization chambers to encourage a wider use of this method.

Dr Rogers drew attention to recent work on charge multiplication effects in ionization chambers when used at high voltages (CCRI(I)/99-24). These effects had been shown to cause errors in the determination of ion recombination correction factors using two-voltage techniques, particularly in the case of parallel-plate chambers. Dr Laitano commented that charge multiplication was a common problem with plane-parallel chambers, but it did not normally present difficulties with cylindrical chambers.

5.6 Development of the graphite calorimeter

The BIPM has obtained a graphite calorimeter from the OFMET. The calorimeter is in good working order, but the data acquisition system will need to be updated.

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* Boutillon M., Volume recombination parameter in ionization chambers, *Phys. Med. Biol.*, 1998, **43,** 2061-2072.

6 DEVELOPMENT AND IMPROVEMENT OF NATIONAL STANDARDS FOR PHOTON DOSIMETRY

6.1 Air kerma

Dr Takata described calculations that had been carried out to determine the energy spectra from the ETL ^{60}Co source (CCRI(I)/99-28). Spectra had been calculated at several points in the exposure room, both with and without a tungsten attenuator.

6.2 Absorbed dose to water

Prof. Hohlfeld presented results of heat transport calculations that had been carried out for PTB water calorimeter vessels of varying dimensions. It had been shown that by using thin glass walls (0.3 mm) and restricting the post-irradiation extrapolation period to 60 s, it was possible to reduce corrections for heat transfer from the walls to 0.1 %. With more robust, thicker wall designs the corrections were larger but comparison with experiment had shown that corrections factors could be calculated with an uncertainty of around 0.1 %.

Dr Rogers described heat transport calculations for the NRC sealed-water calorimeter, which had helped resolve differences in response observed when the calorimeters were operated at 4 °C and 22 °C (CCRI(I)/99-24). In July 1998, the NRC changed the basis of its disseminated ^{60}Co absorbed dose to water standard from a graphite calorimeter to the sealed-water calorimeter operated at 4 °C. The effect had been to increase measured doses by approximately 0.9 %.

Dr Seltzer outlined the history of the NIST ^{60}Co absorbed dose to water standard (CCRI(I)/99-8). Before 1991, the disseminated NIST standard was based on graphite calorimetry, but since that time several variants of water calorimetry had been introduced and the disseminated standard based on a weighted mean of several systems. By 1998, it had become apparent that the most accurate standard was based on hydrogen-saturated sealed-water calorimetry and the disseminated standard is now based solely on this. Despite these changes to the underlying standard, the disseminated value has changed by less than 0.2 % over the period.

Dr Chauvenet described work under way at the BNM-LPRI to establish absorbed dose to water standards for photons from 4 MV up to 25 MV (CCRI(I)/99-18). Initially, calibrations have been based on ^{60}Co primary standards, with transfer to higher energies via ionization chambers and Fricke dosimeters. Work has begun on the development of direct high-energy standards based on graphite calorimetry and Fricke dosimetry. A project for a water calorimeter had also been started.

7 DISSEMINATION OF $N_{D,W}$ CALIBRATION FACTORS

7.1 Comparison of $N_{D,w}$ and N_K

Results of $N_{D,w}$ and N_K comparisons were presented by Dr Aalbers, Prof. Andreo and Dr Boas. It was pointed out that comparison data are complicated by the different underlying standards used. In the case of calibrations traceable to the BIPM ^{60}Co standards, absorbed dose determinations based on N_K (using the TRS 277 protocol) and on $N_{D,w}$ directly, differed by approximately 1 %. All NMIs were encouraged to report to the next meeting with their measurements of $N_{D,w}/N_K$ together with the standard uncertainty and the number of chambers of each type that had been measured. The IAEA already had a substantial data set and comparison would help to identify inconsistencies in chamber behaviour.

7.2 New codes of practice

Various new codes of practice for absorbed dose are being disseminated and reports on these and the consequent recommendations were presented.

- ICRU: The report on "Absorbed Dose Standards for Photon Irradiation and their Dissemination" had been approved and publication is expected in the spring of 2000. The dosimetry of high-energy beams is based on standards of absorbed dose to water.
- IAEA: Prof. Andreo gave an outline of the new IAEA code of practice. The document was, in effect, a set of codes for different radiations, plus

some common chapters. An important change from previous codes of practice is that low- and medium-energy x-ray dosimetry is based on $N_{D,w}$. This has the advantage that all radiation types and qualities are based on the same formalism, although it was recognized that at present only one standards laboratory provided low- and medium-energy x-ray calibrations in terms of $N_{D,w}$. The use of experimental, rather than generic, k_Q values is recommended, although calibration at all qualities need only take place every second or third calibration. The code includes detailed worksheets, which it was hoped would minimize human errors. Prof. Andreo stressed that the code should be seen as an international code, not an IAEA code, as it would be published jointly by the IAEA, ESTRO, WHO and the PAHO.

- AAPM: Dr Rogers reported that the AAPM-TG-51 protocol on external beam dosimetry had been approved in 1998 and publication was expected in autumn 1999.

No other new codes of practice were reported as being in wide use.

8 OTHER NATIONAL STANDARDS FOR PHOTON DOSIMETRY

8.1 Standards for brachytherapy

Dr Seltzer reported that the NIST had introduced a new brachytherapy standard based on a wide-angle free-air chamber (WAFAC). The new configuration was necessary to accommodate new designs of iodine seeds (CCRI(I)/99-7). It also corrected a defect in the earlier standard arising from characteristic x-rays produced from the titanium cladding of seeds. The new and old standards differ by approximately 10 %, the standard uncertainty of the new standard being at the 1 % level.

8.2 Standards for radiation protection

Dr Aalbers reported that preliminary results of a EUROMET comparison of primary air kerma standards for x-ray qualities used in diagnostic radiology were given in document CCRI(I)/99-29. Overall, the comparison had demonstrated satisfactory agreement between the participants (BEV, BIPM, ENEA, NMi, NPL, PTB).

Prof. Andreo expressed concern about the spectra of x-ray beams being used by standards laboratories for mammography calibrations. He felt the use of tungsten anode tubes to give an ISO quality, instead of molybdenum or rhodium, could introduce errors in chambers having poor energy dependence.

It was agreed that there should be a separate agenda item covering diagnostic radiology dosimetry at future CCRI(I) meetings.

8.3 Standards for radiation processing

Dr Burns presented a preliminary analysis of data from the high-dose comparison coordinated by BIPM in 1998 (CCRI(I)/99-17). Six laboratories (ENEA, IAEA, NIM, NIST, NPL, PTB) plus the BIPM had participated. Alanine dosimeters supplied by the NIST and the NPL had been irradiated by each of the participants before being returned to the originating laboratory for measurement. Three nominal dose levels of 5 kGy, 15 kGy and 30 kGy had been used except by the BIPM, who irradiated to a nominal 1 kGy in their therapy irradiator. The results show agreement by all participants within the combined standard uncertainty (≈ 1.7 %). It was agreed that the results of the comparison be submitted for publication to an appropriate radiation processing journal, probably *Radiation Physics and Chemistry*.

9 DEVELOPMENT AND IMPROVEMENT OF NATIONAL STANDARDS FOR CHARGED PARTICLE DOSIMETRY

9.1 Electron beams

Dr Sharpe reported that the first user calibrations of the therapy-level electron beam absorbed dose to water service had taken place in the summer of 1998 (CCRI(I)/99-20). A direct calibration of alanine dosimeters in electron beams had been carried out by embedding alanine pellets in a replica core of the primary standard electron beam calorimeter. The agreement at 10 MeV between electron and photon calibrations of alanine was within 0.6 %. Analysis of data at 6 MeV and 16 MeV was still in progress. A phantom consisting entirely of alanine dosimeter material had also been constructed. Analysis of depth dose curves in this phantom enabled an experimental verification of the stopping powers given in ICRU 37 to be achieved.

9.2 Beta-ray fields

Dr Seltzer commented that preliminary results of a comparison of ophthalmic applicator dosimetry were given in CCRI(I)/99-9. The work had been stimulated by an ICRU Report Committee. Agreement seemed to be around 10 % (1 σ).

Prof. Hohlfeld stated that work on ophthalmic applicator dosimetry was under way at the PTB using an extrapolation chamber with high spatial resolution.

9.3 Proton beams

Prof. Hohlfeld stated that some proton calorimeter work was being carried out at the PTB but as the uncertainties were rather large, it was too early to identify the system as a dosimetry standard.

10 STATUS REPORTS AND ADDITIONAL INFORMATION FROM MEMBER LABORATORIES

Laboratory representatives briefly introduced the written reports describing the work of their institutes. In some cases, additional comments were given as indicated below:

- BEV (CCRI(I)/99-7): a mammography project is just starting at the BEV and a questionnaire has been distributed to interested laboratories requesting details of qualities etc.
- NIST (CCRI(I)/99-7).
- OMH (CCRI(I)/99-14): Dr Csete offered a waterproof chamber developed at the OMH for use in the CCRI(I) calibration comparison.
- ARPANSA (CCRI(I)/99-11): Dr Boas explained that the Australian Radiation Laboratory (ARL) and the Nuclear Safety Bureau had been merged in February 1999 to form a new organization known as the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).
- APMP (CCRI(I)/99-13): Dr Boas introduced the report of the Technical Committee on Ionizing Radiation of the Asia-Pacific Metrology Programme (APMP).
- NIM (CCRI(I)/99-15): Dr Tian Zhongqing mentioned in connection with the high-dose comparison that Fricke dosimetry had been used as the basis of the NIM standard, the "G-value" being a combination of published values and experimental results. Exposure standards were still being disseminated for x- and gamma rays, but air kerma standards were to be introduced in the near future. It is planned to restart work on graphite calorimetry.
- PTB (CCRI(I)/99-16): Prof. Hohlfeld reported that the microtron, used as part of the absorbed dose primary standard, had been unserviceable for two years and that work was under way to move to an absorbed dose standard based on a water calorimeter.
- BNM-LPRI (CCRI(I)/99-18): Dr Chauvenet explained that building work had meant that the BNM-LPRI had been unable to take part in the high-dose comparison. The name of the institute would shortly change to

Laboratoire National Henri Becquerel (BNM-LNHB). Work on x-ray standards was carried out at a separate institute (BNM-LCIE), but would be included in future reports to CCRI(I). The BNM-LPRI now has a therapy ^{60}Co irradiator in place of the "pure" beam used previously.

- VNIIM (CCRI(I)/99-19): in introducing the report from the VNIIM, Dr Villevalde explained that at present eight people are working in the dosimetry group.
- NPL (CCRI(I)/99-20).
- ENEA (CCRI(I)/99-21): Dr Laitano stated that it had been decided to operate the sealed-water calorimeter at 4 °C, rather than at ambient temperature, as had been used previously.
- NMi (CCRI(I)/99-23): comparisons at the CCRI qualities at the BIPM were mentioned as well as mammographic dosimetry comparisons with the PTB and the NPL.
- NRC (CCRI(I)/99-24).
- ETL (CCRI(I)/99-28).

11 REPORTS FROM INTERNATIONAL OBSERVERS

11.1 ICRU

Dr Seltzer reported on current ICRU activities. ICRU Report 60 "Fundamental Quantities and Units for Ionizing Radiation" has been published. It includes a definition of the new quantity *cema* for charged particles. Reports on "Beta Rays for Therapeutic Applications", "Dosimetric Procedures for Diagnostic Radiology" and "Stopping Powers for Heavy Ions" are in preparation. A seminar on high-dose dosimetry to be presented by Dr Sharpe is planned for the 1999 meeting of the ICRU.

11.2 IAEA

Prof. Andreo introduced the report from the IAEA (CCRI(I)/99-5). A number of topics in the report, including the development of the new dosimetry code of practice, had already been covered earlier in the meeting. Prof. Andreo was particularly encouraged by improvements in the operation of the IAEA/WHO thermo-luminescent dosimeter postal service to hospitals, reporting that a 90 % return rate of dosimeters was now being achieved.

There were no representatives present from the IOMP or the IRPA and no written reports had been submitted.

12 PUBLICATIONS

The increased use of electronic methods of publication and communication were discussed. The BIPM is planning to include a list of publications from NMIs on its web pages and participants were asked to supply details of publications in either Word or HTML format. Attention was also drawn to the fact that certain information available to CCRI(I) members is confidential and should not be published on web pages. Where possible, e-mail link servers should be used to distribute information to all members of working groups.

13 OTHER BUSINESS; DATE OF NEXT MEETING

It was noted that many papers submitted to the meeting for inclusion as official CCRI(I) documents had been received very late, with a number being tabled during the meeting itself. This did not give time for adequate consideration and it was agreed that stricter control was needed. Papers for

inclusion as CCRI(I) documents must be submitted at least six weeks before the meeting to enable NMIs to have at least one month to review the contents. Papers submitted after that date will only be included in exceptional circumstances and with the agreement of the CCRI(I).

A meeting in the spring of 2001 was felt to be necessary. The CIPM would advise the actual date at their meeting in October 2000.

The Chairman concluded the meeting by thanking all the participants for their presentations and the useful discussions which had been provoked. A busy time ahead was predicted for all the NMIs to ensure that their degrees of equivalence and calibration capabilities were appropriately presented for inclusion in the BIPM key comparison database. He stressed the importance of ensuring that uncertainty budgets were carefully constructed and consistent.

Finally he reminded everyone of the opportunity to visit the Ionizing Radiation laboratories and thanked the BIPM for its hospitality.

P. Sharpe, Rapporteur

September 2000

APPENDIX R(I) 1.
Working documents submitted to Section I of the CCRI at its 14th meeting

(see the list of documents on page 57)

Consultative Committee for Ionizing Radiation

Section II: Measurement of radionuclides

Report of the 15th Meeting

(31 May–2 June 1999)

Agenda

1 Opening of the meeting; approval of the agenda; appointment of a rapporteur.

2 Report of the fifteenth meeting of the CCEMRI.

3 International comparisons of activity:

- 3.1 Results of the full-scale ^{204}Tl comparison;
- 3.2 The ^{152}Eu trial comparison;
- 3.3 Status of publication of the completed ^{75}Se comparison.

4 The International Reference System:

- 4.1 Status report;
- 4.2 Efficiency curves.

5 Extension of the International Reference System:

- 5.1 Status report on the BIPM liquid scintillation counting system;
- 5.2 ^{90}Sr comparison;
- 5.3 Future of the extended International Reference System.

6 Reports of the working groups:

- 6.1 High-efficiency detection systems;
- 6.2 The extended International Reference System;
- 6.3 Future comparisons;
- 6.4 The SIR database;
- 6.5 Equivalence;
- 6.6 ^{192}Ir trial comparison;
- 6.7 Realization of the becquerel at the basic level.

7 New working group.

8 Future international comparisons.

9 The BIPM programme.

10 Review of recent work and projects in member laboratories.

11 Visit to the BIPM laboratories.

12 Other business.

Abstract

Section II (Measurement of radionuclides) of the Consultative Committee for Ionizing Radiation (CCRI) held its fifteenth meeting at the Pavillon de Breteuil, Sèvres, on 31 May, 1 and 2 June 1999. The principal discussions centred on the Mutual Recognition Arrangement (MRA), with decisions on the establishment of equivalence and the central role that the International Reference System (SIR) will play in this for radioactivity standards. The Equivalence Working Group was charged with examining how a rolling programme of updating could be achieved without placing excessive strains on the resources of individual national metrology institutes (NMIs). It was agreed that the ^{204}Tl comparison results were unacceptably discrepant and a working group was established to review the standardization techniques and other influencing factors in order to determine why such differences exist. A report was commissioned on the problems relating to the standardization of ^{192}Ir before a full-scale comparison could be conducted. The ^{152}Eu comparison had just begun following some significant delays and new comparisons of ^{89}Sr and ^{238}Pu are planned for the year 2000. Progress was reported on the studies into a realizable ionization chamber. The extension of the SIR via liquid scintillation counting was discussed at some length, particularly in respect of maintaining reproducibility over extended periods of time. A monograph on the conventional liquid scintillation technique using the CIEMAT/NIST method is being produced and alternative proposals are to be formulated for discussion. Details were presented about the ongoing work at the BIPM, especially as it relates to the enhancement of the SIR ionization chamber data, and the proposed extensions to the BIPM's standardization facilities via the triple-to-double coincidence ratio technique (TDCR).

1 OPENING OF THE MEETING; APPROVAL OF THE AGENDA; APPOINTMENT OF A RAPPORTEUR

Section II (Measurement of radionuclides) held its fifteenth meeting at the Pavillon de Breteuil, Sèvres, on 31 May, 1 and 2 June 1999.

The following were present: D. Alexiev (ANSTO), N. Coursol (BNM-LPRI), Y. Hino (ETL), H. Janβen (PTB), L.R. Karam (NIST), J.M. Los Arcos (CIEMAT), G. Moscati (President of the CCRI), T.S. Park (KRISS), T.J. Quinn (Director of the BIPM), B.R.S. Simpson (Chairman of Section II, NAC), L. Szücs (OMH), T. Terlikowska-Drozdiel (RC), N.D. Villevalde (VNIIM), M.J. Woods (NPL), Yang Yuandi (NIM).

Observers: P. De Felice (ENEA), W. de Vries (NMi-VSL).

Personal members: J.-J. Gostely (IRA), G. Winkler (IRK).

Also attending the meeting from the BIPM: P. Giacomo (Director Emeritus), P. Allisy-Roberts (Executive Secretary of the CCRI), C. Michotte, G. Ratel and C. Thomas (BIPM).

Apologies were received from the IRMM, LNMRI and NRC.

The Director of the BIPM, T.J. Quinn, opened the meeting by welcoming the participants. He noted that the meeting was being held in parallel with a meeting of Section III and that they would join the Section II meeting for a joint presentation on the Mutual Recognition Arrangement because of the common interests for both groups.

B.R.S. Simpson, the Chairman, commenced by welcoming the participants and, in particular, the seven new delegates. Members then introduced themselves. In addition to the regular attendees, C. Thomas (BIPM) was in attendance in her role as coordinator of the BIPM key comparison database. The Chairman reiterated that this was a consultative meeting, charged with providing recommendations and guidance to the BIPM on the conduct of relevant comparisons and associated activities, as well as allowing the BIPM staff to report the results of their ongoing work. The Chairman reviewed the progress reported in the two previous nine-monthly reports [CCRI(II)/99-1 and 32]. He emphasized those items still outstanding, all of which were discussed in detail at the appropriate agenda item. The previous Chairman (K. Debertin) had made a strong recommendation that more effort should be

made to ensure that reporting deadlines must be met. It was proposed that this would be discussed later in the agenda together with the possibility of changing corresponding schedules.

It was noted that some of the working group coordinators were unable to attend the meeting.

The meeting confirmed the appointment of M.J. Woods as Rapporteur.

The agenda was approved with the addition of a presentation and discussion on the MRA (Section 6.5.1).

2 REPORT OF THE FIFTEENTH MEETING OF THE CCEMRI

A brief summary was presented of the report of the fifteenth meeting of the CCEMRI. Equivalence had been discussed, particularly in respect of its relevance to Sections I, II and III of the CCRI (new name given to the CCEMRI). One of the principal decisions was that all NMIs with the relevant standards would be included in any equivalence database. As a particular point, Section II was asked to consider the possibility of making comparisons of alpha-emitting radionuclides and to look at standardizations for short-lived radionuclides. As neither of these items appeared on the agenda for the CCRI(II), it was suggested that, following subsequent CCRI meetings, any such specific actions should be highlighted to members. It was also suggested that e-mail should be used more widely for communication and so delegates at CCRI(II) were advised to check the accuracy of their contact details on the BIPM website.

The proposed list of members for Section II of CCRI was approved. This included new members from the RC (Poland), the CIEMAT (Spain), the ETL (Japan), the IRMM (EC) and the KRISS (Korea) as well as observers from the CMI (Czech Republic), the ENEA (Italy), the LNMRI (Brazil) and the NMi-VSL (The Netherlands) and the international bodies ICRU and IOMP.

3 INTERNATIONAL COMPARISONS OF ACTIVITY

3.1 Results of the full-scale ^{204}Tl comparison

G. Ratel presented the ^{204}Tl trial comparison results which are contained in *Rapport BIPM*-97/3. The full comparison results were also presented with laboratory identities replaced by code numbers in anticipation of the adoption of the MRA recommendation for anonymity until agreement had been reached by the participants. The data indicated two distinct groups of results, namely those produced using liquid scintillation (LS) counting techniques (with a small spread and one or two outliers) and those by other methods. Several comments and possible reasons for discrepancies were documented in CCRI(II)/99-24, namely:

- some adsorption in the ampoule walls was seen by two laboratories;
- one laboratory had used a home-made LS spectrometer with only one photomultiplier;
- another had used two methods (TDCR and $4\pi\beta$) but had produced no significant differences;
- $4\pi\beta$-γ-coincidence tracer efficiency methods with ^{60}Co seemed more consistent than those with^{137}Cs and the suitability of tracers needs to be investigated;
- differences existed between carrier and acid concentration values for the trial and full comparisons;
- the energy spectra of the two sets of sources (full and trial) showed no obvious differences, indicating absence of impurity;
- the results in 1964 using the SO_4 form in 1 mol/dm^3 HNO_3 appeared to give better results, indicating a need to examine further the effects of chemical composition;
- the liquid scintillation results were essentially identical but the close agreement between the LS CIEMAT/NIST methods may hide some problems since the same software supplied by the CIEMAT is mostly used;.
- it was possible that there was more self-absorption in the solid sources;
- an influence of source size for solid sources had been noted by the IRMM.

M.J. Woods raised additional comments arising from the proposed ICRM presentation [CCRI(II)/99-24], which he felt needed further investigation:

i) static electricity problems related to weighing and deposition;

ii) apparent differences in the uncertainties related to the tritium standards used and to the interpolation of calibration curves;

iii) uncertainties attributable to the activity of the tracer;

iv) uncertainty estimates for weighing and counting statistics which appear to be different for LS counting and other methods;

v) correlations arising from the use of the same algorithms for LS counting;

vi) effects of adsorption, particularly for future comparisons.

Y. Hino had conducted further measurements using ^{60}Co and ^{134}Cs as tracers and had not seen any difference between the extrapolated results for these two tracers. He had concerns that the comparison results might be count-rate dependent. Some previous tracer-efficiency measurements using much higher activity concentrations had produced satisfactory agreement between the 4πβ-γ-coincidence measurements and those from LS techniques. A question was raised as to whether the LS measurements covered a wide range of quenches or whether they were all very similar. G. Ratel agreed to examine this.

The IRMM had used three different methods, obtaining LS results in agreement with the other LS values, but their 4π pressurized proportional counter and 4π CsI results were 4.6 % lower. They had identified effects which indicated that the activity values (N_o) were dependent on source quality. An improvement in the source drying technique had improved results. The size of the source substrate had also been seen to have an influence on the measured activity concentration.

Following a general discussion about the comparison and the 10 % spread in the results, M.J. Woods proposed that as there were still significant problems, the comparison should not be used either to establish key comparison reference values or to establish equivalence. It was agreed to delete the comparison from the database.

M. Woods further proposed that a meeting be arranged between interested parties who were familiar with each of the measurement techniques employed in order that all of the problems could be discussed and actions approved which would seek to resolve the existing metrology problems. This was agreed. A working group was established (G. Ratel (Coordinator), N. Coursol, P. De Felice, D.F.G. Reher, T. Terlikowska, M.J. Woods) with the task of arranging the meeting at the BIPM and its agenda.

3.2 The ^{152}Eu trial comparison

There had been problems in procuring samples from the commercial market with sufficiently low levels of impurity. Accordingly, the PTB had accumulated sufficient material from existing stocks. These comprised approximately 26 mg/dm^3 Eu in 0.1 mol/dm^3 HCl and, having been measured in the SIR ionization chambers, were dispatched to the participants of the trial comparison (BNM-LPRI, ETL, NRC, OMH, PTB) during the week preceding the CCRI(II) meeting. The carrier content would be re-examined by the PTB using x-ray fluorescence. It was agreed that the NPL would join the comparison and that the PTB would send the remaining ampoules to G. Ratel for measurement in the SIR: one of these would then be dispatched to the NPL. The reporting deadline for the participants is 13 September 1999 and, provided the results are satisfactory, ampoules would then be dispatched to all those others who had indicated that they wished to take part in the full comparison. The results from the trial comparison would be included in the full comparison results, removing the need for these participants to make further measurements.

N. Coursol presented the latest measured values for the half-life of ^{152}Eu which had been combined with previously published results using the IAEA-TECDOC-619 evaluation criteria. This produced a value of (4939 ± 37) d ($k = 1$). It was agreed that this value would be used for the comparison and communicated to participants. There is about 0.7 % ^{154}Eu in the sample and it was approved that G. Ratel should recommend to participants that they measure this accurately and make appropriate corrections.

3.3 Status of publication of the completed ^{75}Se comparison

All ampoules used in this comparison had been measured in the BIPM ionization chambers and no impurity had been detected by the NIST, NPL or PTB. No adsorption in the ampoules had been detected. Results were presented both before and after correction for the delayed events: a few outliers were noted. In total, seven different measurement techniques were employed by the twenty-one participants. The results before correction for delayed events showed a 6.6 % spread neglecting one significant outlier: this reduced only to 6.0 % after corrections were applied. The half-life of the delayed state had been measured by the BIPM and NPL and their results were in good agreement with the published values. The principal conclusion was that the results demonstrated the difficulty in standardizing this particular

radionuclide. A preliminary report has now been produced and comments are awaited from the participants before proceeding to publication.

The possibility was raised that the results could be biased by the literature values that participants had selected for the delayed state. It would be instructive to review the results to determine whether there would be any improvement if all participants used the same nuclear data.

4 THE INTERNATIONAL REFERENCE SYSTEM

4.1 Status report

Over the last two years, 16 laboratories submitted 72 ampoules covering 32 radionuclides: three of these (^{153}Sm, ^{186}Re and ^{237}Np) were submitted for the first time. The number of independent values submitted was 59 of which 4 were subsequently withdrawn. One laboratory, the BEV, had submitted samples for the first time. Since the SIR commenced, 762 samples have been submitted representing 535 independent results from 26 laboratories for 59 different radionuclides. A total of 39 results had been subsequently withdrawn.

It was not known how many submissions were the results of direct standardizations on the submitted material rather than from secondary standard systems which had been calibrated previously as the result of other direct standardizations at the submitting laboratory.

L. Karam tabled some NIST measurements which illustrated that correction factors are required for the effect of density and carrier concentrations in the assay of ^{144}Ce, ^{153}Sm and ^{153}Gd. Similar effects seem to be observed at the BIPM with ^{241}Am where a possible 0.7 % increase in equivalent activity had been noted with acid strengths of 0.1 mol/dm^3 to 3 mol/dm^3 HCl, corresponding to a density range of 1.0 g cm^{-3} to 1.1 g cm^{-3}.

The change in the recommended half-life value of ^{56}Co from 78.76 d to 77.31 d, as a result of IAEA TECDOC-619, had made a significant improvement in the agreement between submitted SIR samples. It was agreed that the SIR should use the IAEA compiled data wherever possible. It was noted that the 1991 IAEA compiled data are currently being revised.

4.2 Efficiency curves

^{153}Sm had been submitted for the first time but contained impurities of ^{154}Eu and ^{156}Eu. Since the latter is not in the SIR database, it has been necessary to predict its response using published nuclear data and the SIR efficiency curves.

Differences in measured impurity levels at the BIPM and the NIST have been resolved [CCRI(II)/99-21]. The influence of the high-energy beta particle emissions in ^{156}Eu was also estimated. More submissions of ^{153}Sm were required. The PTB had made a recent submission: the NPL and ANSTO also agreed to submit samples.

The method of updating the SIR ionization chamber efficiency curve was presented. Standard available software is used to determine the fit and the uncertainties of the efficiency curve. The data for ^{67}Ga did not fit the curve well but if recent NAC measurements on this radionuclide are used, which suggest the value of the 93.3 keV gamma emission probability should be changed from 39 % to 37.4 %, then the fit improves.

In response to a question about the beta particle emission response, it was stated that A. Rytz had made measurements on this and C. Michotte agreed to revisit this data.

5 EXTENSION OF THE INTERNATIONAL REFERENCE SYSTEM

5.1 Status report on the BIPM liquid scintillation counting system

Stability and reproducibility measurements are being made with sources of ^{99}Tc. Sources of ^{169}Er and ^{89}Sr have also been received recently from the PTB: these are being measured at the BIPM.

5.2 ^{90}Sr comparison

The comparison was completed with eleven participants submitting samples in 0.1 mol/dm^3 HCl to 1 mol/dm^3 HCl and one submitted as 0.1 mol/dm^3 HNO_3. Sources were generally $SrCl_2$ + YCl_3 but two were in the nitrate form. Activity levels ranged from 4 kBq g^{-1} to 800 kBq g^{-1}. Aliquots

from each sample were adjusted to provide counting rates below 20 000 counts per second. Five quenched standards of tritium were also produced. The major uncertainty arose from the quench, being of the order of 0.27 %. Comparing submitted results with those measured by the BIPM, we obtained a ratio from 0.995 to 1.001 for all measurements, except one at 0.983. There was no significant difference between the unweighted mean, weighted mean and median. The low value corresponded to the Cl_3^- form in HNO_3 and this sample also displayed some instability. A report is to be issued on this comparison.

5.3 Future of the extended International Reference System

The discussion widened to the extended International Reference System as a whole, covering a number of topics.

The need to institute a system guaranteeing reproducibility of scintillant composition and purity and of sample containers was raised. It was claimed that this was not necessary if the CIEMAT/NIST method is used: the use of a tritium standard eliminated these problems. The stability of scintillants during transport was mentioned as was the need for the BIPM to make activity measurements which are not required for the SIR ionization chamber system.

An alternative approach was suggested using liquid scintillation counting, without the CIEMAT/NIST model, relying on known efficiency curves and quench factors. It was suggested this would avoid the measurement of activity at the BIPM and hence follow the normal SIR philosophy. Under such a scheme, NMIs could either send active solutions to the BIPM which would then be dispensed into scintillants for assay, or conversely the BIPM would send vials containing scintillant to the NMIs who would add activity for assay subsequently at the BIPM. It was debated that this might require as many efficiency curves as there are scintillants since not every scintillant is suitable for every radionuclide. A knowledge of the chemical form would also be needed. It was agreed that P. De Felice would send documented proposals to the BIPM for circulation to, and comment by, Section II members. G. Ratel agreed to make exploratory measurements once the proposal had been submitted. It was agreed that P. De Felice would become a member of the Extended SIR Working Group.

It was agreed that the outstanding action on the existing Extended SIR Working Group to produce a monograph on liquid scintillation counting would be carried forward by its new coordinator, J.M. Los Arcos. The aim is

to complete this before the BIPM liquid scintillation system moves to its new laboratory where the temperature and humidity will be controlled.

6 REPORTS OF THE WORKING GROUPS

6.1 High-efficiency detection systems
(Coordinator: Prof. G. Winkler)

G. Winkler presented the general layout of the proposed monograph. The sections would include

i) advantages and drawbacks with particular emphasis on the effects on accuracy;

ii) potential efficiencies of these systems and simulation techniques;

iii) the realization of such systems based both on traditional methods of calculation using published data on such items as attenuation coefficients and typical set-ups including 4π geometries;

iv) efficiency values for typical systems;

v) evidence from comparisons of such systems;

vi) bi-4π systems where $4\pi\beta$ detectors are enclosed in $4\pi\gamma$ detectors geometries. These allow efficiency extrapolations by moving the β detector relative to the γ detector, changing ε_γ rather than ε_β.

This working group will probably close at the end of 1999 following the production of the monograph.

6.2 The extended International Reference System
(Coordinator: Dr A. Grau Malonda)

See Section 5.3.

6.3 Future comparisons (Coordinator: Dr Á. Szörényi)

Á. Szörényi had changed responsibilities at his institute and would no longer be able to act as coordinator: no report had been issued. Previous questionnaires had identified ^{55}Fe, ^{85}Sr, ^{90}Sr and ^{153}Gd as being high priorities. During the discussion both ^{89}Sr (medical applications) and ^{238}Pu

(environmental applications) were tabled as being of highest priority. It was agreed that comparisons should be conducted of both. It was decided that the PTB would provide samples for a full-scale ^{89}Sr comparison to be conducted (without a trial) in the first half of the year 2000. There was agreement that the NMI which would produce the ^{238}Pu samples would be decided by joint discussions between the NPL and the NIST during the ICRM meeting in Prague (Note: at the ICRM meeting, the NPL agreed to provide the samples) and that the full-scale comparison be scheduled for the second half of the year 2000. It was also resolved that the BIPM should coordinate both exercises and would enquire of member laboratories to determine the participation level.

Section II decided that it was no longer necessary to continue with this working group and that, in future, suggestions for comparisons should be sought from members when the agendas for future meetings are distributed. Both proposals were approved**.**

6.4 **The SIR database** (Coordinator: Mr D.F.G. Reher)

In the absence of the coordinator, G. Ratel summarized the current position [CCRI(II)/99-11]. The accuracy of the data has been checked and some minor changes have been implemented in order to remove ambiguities. It was decided that the data be published in a BIPM monograph by the end of 1999. There are some outstanding issues to be resolved:

a) It is believed that the entries from some NMIs may be based on an ionization chamber that has been calibrated by another NMI. In this event they should be noted as such and not used in the derivation of any key comparison reference value.

b) The latest entry date for the monograph will be the end of March 1999.

c) The data from the ^{192}Ir trial comparison should be withdrawn from the database (see Section 6.6).

d) All submissions to the database since its beginning other than those already withdrawn should remain in the database.

It was agreed that these points would be addressed by the BIPM and that the working group should continue with its present coordinator and composition.

6.5 **Equivalence** (Coordinator: Mr M.J. Woods)

6.5.1 Equivalence and the Mutual Recognition Arrangement

The Director of the BIPM, T.J. Quinn, addressed a joint gathering of both Sections II and III. The objective was to bring members up to date on the latest developments and to explain how the system would operate in practice. He stressed the underlying requirements which have led to the need for the Mutual Recognition of National Measurement Standards and of Calibration and Measurement Certificates Issued by National Metrology Institutes. The time had passed when existing *ad hoc* arrangements could be regarded as satisfactory and an open, transparent and comprehensive scheme is needed. The objectives are to establish the degree of equivalence of national measurement standards and to provide confidence for the recognition of calibration and measurement certificates. It was emphasized that all signatory NMIs of the MRA with the relevant standards would be included: none would be excluded.

The MRA is divided into two sections. The first relates to the mutual recognition of national standards and is based on key comparisons. The second addresses the mutual recognition of calibration and measurement certificates issued by NMIs. The process leading to this latter recognition involves the use of key comparisons, supplementary comparisons, the introduction of quality systems together with demonstrations of competence and an overseeing role by the Joint Committee of Regional Metrology Organizations and the BIPM.

It was stressed that key comparisons need to be carefully chosen by the Consultative Committees to demonstrate the capabilities of NMIs without the need to compare all measurement standards in any particular area. To this end, guidelines for comparisons had been drawn up, with the latest version being produced in March 1999. An important aspect in this latest version is that results in comparisons will not be accepted unless they are accompanied both by uncertainties and uncertainty budgets. Additionally, participating laboratories can no longer withdraw their results without the agreement of all participants. Any withdrawal has to be supported by very sound technical reasons: difference from other results could not be regarded as a sound reason on its own. The raising of the profile of uncertainty estimates was noted as a very important outcome of the current activity.

In response to a question, it was made clear that judgments on calibration and measurement capabilities were not the responsibility of the Consultative Committees.

Concerns were expressed that small laboratories might be forced out of existence by the new arrangement and that they would have to rely on standards from other laboratories. T.J. Quinn reaffirmed that this was not the intention and there was confidence this would not happen.

Section II then debated the issues relating to the establishment of key comparison reference values and degrees of equivalence for radioactivity standards. The working group had met several times to discuss the practical implementations. Their recommendations were encapsulated in the draft of a paper due to be presented the following week at the ICRM meeting in Prague. The general approach proposed by the Equivalence Working Group was supported. The principal discussions centred around the problems associated with a ten-year cut-off period being adopted by other Consultative Committees and the type of mean value that would be used to determine the reference activity. Given the number of radionuclides for which equivalence needed to be established, neither the NMIs nor the BIPM would have the resources to commit to supporting the number of key comparisons that would be required each year to accommodate a ten-year renewal programme based on either full-scale comparisons or even SIR submissions. Concerns were expressed that a renewal system was needed to ensure that standardization capabilities were being maintained despite changes in personnel and equipment. It was agreed that, for now, equivalence would be based on the SIR without any time cut-off. This would need to be re-examined in the future with the objective of producing an acceptable rolling programme of updates.

Within this re-examination, it was agreed that the Equivalence Working Group should consider whether the use of generic standardizations could be used to lighten the load on the NMIs and the BIPM. However, it was made very clear that reference values could not be based on generic methods. A particular strength of the radioactivity community is the variety of independent methods used within it but it is not acceptable to produce, for a particular radionuclide, a range of reference values which depend on the method used.

Although the median had been proposed at the previous CCRI meeting as the basis for determining the reference activity, the Equivalence Working Group had concluded during its deliberations that there were sound arguments against the median and that the unweighted mean should be used. The principal reason for the rejection of the weighted mean was that the reference activity would be based on submissions to the SIR over the past twenty-five years or more and that the quality of uncertainty estimations had changed significantly during that period. Furthermore, differences existed between

estimations from different NMIs. A wide-ranging discussion followed and it was agreed that, for the interim, both the unweighted mean and the median would be calculated and documented in the database which determined the reference activity. It was also approved by a large majority that the unweighted mean would be used as the best estimate of the SI value. For the degree of equivalence between NMIs, the reference activity and its uncertainty disappear from the calculation.

It was noted that the MRA does not allow participants to withdraw results without the agreement of all participants in a comparison. However, the SIR is used not just for the establishment of equivalence but has also been used to allow NMIs to test new measurement methods against conventional techniques. In addition, the non-simultaneous nature of the comparison procedure would make it difficult to operate an agreed withdrawal process. It was agreed therefore that all NMIs would be informed of the MRA decision and that when NMIs submit samples to the SIR they would have to declare in advance whether the sample was being sent for a pilot study or for equivalence purposes. If a pilot study was the purpose, the results would not be used for equivalence purposes.

It was agreed that J.-J. Gostely should join the working group.

A coding system would identify individual comparisons in each Consultative Committee. This would differentiate between the CCRI, BIPM (i.e. SIR) and regional metrology organization comparisons. A list would be distributed to Section II members.

It was decided that each previous full-scale comparison would be re-analyzed using the same principles as applied to the SIR analyses with the results being distributed to members and other participants for comment before being included in the equivalence database.

6.5.2 Other international comparisons

The Technical Committee on Ionizing Radiation of the APMP was currently conducting a comparison of $^{166}Ho^{m}$. There are twelve participants and one ampoule from the comparison set has been sent to the SIR.

Within EUROMET, the ^{237}Np comparison is still ongoing but two ampoules have been submitted to the SIR. The ^{169}Yb comparison is complete but a decision has still to be taken by EUROMET on whether to seek degrees of equivalence through the SIR measured ampoule.

6.6 ^{192}Ir trial comparison (Coordinator: Dr Y. Hino)

To investigate discrepancies in the measurements on ^{192}Ir, Y. Hino (ETL) had obtained and distributed additional material: five laboratories from the APMP had made new measurements. The subsequent report noted that the use of atmospheric counters with NaI gamma detectors may miss the electron capture events: measurements using high-pressure systems and Ge gamma detectors gave higher values. A decision was made that these results would need to be circulated to participants in any future comparison. Y. Hino agreed to produce a report within nine months, detailing the problems associated with the standardization of ^{192}Ir. This would cover all the problems reported and not just those related to the latest mini-comparison. Because of the ongoing problems, it was decided that results from the ^{192}Ir comparisons would be used neither for SIR purposes nor for equivalence.

It was agreed that the working group should continue until Y. Hino had produced the review document. It was also determined that a full-scale comparison would be conducted subsequent to the production of this report and that the BIPM would approve a schedule by correspondence.

6.7 Realization of the becquerel at the basic level (Coordinator: Mr D.F.G. Reher)

In the absence of D.F.G.Reher, M.J. Woods presented the progress to date. At the IRMM, a significant effort had been expended in developing a model of the existing NPL secondary standard ionization chamber using EGS4. The model had produced results which were in reasonable agreement with the experimentally produced calibration figures. The need to obtain exact agreement between theory and experiment is not critical since the principal requirement is to model the effects of variations in constructional details such as dimensions, materials and their purities and gas pressure. Experimental work is being conducted at the NPL to provide data on the energy-dependent effects of varying gas composition and pressure as well as variations in polarizing voltage. The intention is to develop a design before the end of 1999 and to initiate construction of a prototype.

Y. Hino reported on the current work using ^{166}Ho^{m} and the possibility of using this radionuclide as a long-lived reference source. It was noted that current supplies contain some radioactive europium as a contaminant.

7 NEW WORKING GROUP

As discussed in Section 3.1, a ^{204}Tl standardization working group was established.

8 FUTURE INTERNATIONAL COMPARISONS

As discussed in earlier sections the agreed programme of CCRI(II) comparisons is:

- ^{152}Eu. Start date: end of September 1999 subject to satisfactory completion of the trial comparison (deadline for results is 13 September 1999).
- ^{89}Sr. Start date: January 2000. Supplier of samples: PTB. No trial comparison proposed.
- ^{238}Pu. Start date: July 2000. Supplier of samples: NPL. No trial comparison proposed.
- ^{192}Ir. Start date: to be agreed by correspondence following production and dissemination of report by Y. Hino.

9 THE BIPM PROGRAMME

G. Ratel reported on recent developments at the BIPM. These included:

- a revised, PC-based measurement reporting procedure for the ionization chamber systems;
- the ongoing construction of a TDCR system to supplement the facilities for the extension of the SIR;

- the implementation of the selective sampling method used in association with the 4π (pressurized proportional counter)-NaI(Tl) measurement facility;
- the renovation of the 4π (atmospheric proportional counter)-NaI(Tl) measurement facility particularly in respect of data acquisition;
- BIPM-written software for use with the TDCR facility has been undergoing validation. In addition, measurements have been made to compare the BNM-LPRI MAC-3 unit (acquisition module for triple-coincidences) against the existing BIPM modules.

A systematic study has been conducted of the bi-parametric data acquisition system.

C. Michotte gave an outline of the progress that has been made with the Ge(Li) spectrometer which is used primarily for the measurement of impurities in samples submitted to the SIR. Full details of the system, its development and capabilities are contained in *Rapport BIPM*-99/3 which is due to be published. In particular, some examples were given on the effect on the SIR values when improved impurity measurements and the most recent nuclear data were used. A protocol was proposed whereby the SIR values could be adjusted if there are inconsistencies related to impurities and these inconsistencies can be resolved justifiably. It was agreed that the BIPM should document and distribute this protocol to the SIR participants and that the protocol should be used where necessary.

10 REVIEW OF RECENT WORK AND PROJECTS IN MEMBER LABORATORIES

Written progress reports from each member laboratory were circulated and representatives were given the opportunity to present a brief oral report. This session continues to be a valuable forum for outlining the nature and scope of radionuclide metrology activities occurring within member organizations.

It was noted that member laboratories of Consultative Committees have been asked to send a list of their publications produced since the previous meeting. These should be in electronic form where possible and preferably in the

Metrologia reference format. This information would then be added to the BIPM website. It was agreed that members should provide this data.

11 VISIT TO THE BIPM LABORATORIES

Most attendees took advantage of an invitation to visit the laboratories concerned with the maintenance of radioactivity standards.

12 OTHER BUSINESS

It was noted that a list of all past CCRI comparisons since 1970 would be published on the BIPM website.

It was agreed that the requirements for reports from members and working group coordinators would be changed in the following manner:

- Members will provide a biennal report from their NMI by the end of the February before the CCRI(II) meeting.
- Working group coordinators will provide an annual report by the end of February each year.
- All other technical papers to be presented at the CCRI(II) meeting must be received at the BIPM at least four weeks before the CCRI(II) meeting. Any papers not received by that date would only be accepted as CCRI(II) meeting papers if it were agreed unanimously by the CCRI(II).

The Director of the BIPM, who was chairing the final session in the absence of the Chairman, closed the meeting by thanking those present for their contributions and, in particular, expressed his gratitude to the staff of the BIPM for all their efforts.

M.J. Woods, Rapporteur

July 1999

revised September 2000

APPENDIX R(II) 1.
Working documents submitted to Section II of the CCRI at its 15th meeting

(see the list of documents on page 85)

Consultative Committee

for Ionizing Radiation

Section III: Neutron measurements

Report of the 13th Meeting

(31 May–1 June 1999)

Agenda

1 Opening of the meeting; approval of the agenda; appointment of a rapporteur.

2 Report of the fifteenth meeting of the CCEMRI.

3 Mutual Recognition Arrangement.

4 Comparison of measurements of 24.5 keV fluences.

5 Review of previous key comparisons and plans for further measurement comparisons:

- 5.1 Comparison of measurements of thermal neutron fluence rates;
- 5.2 Comparisons of measurements of monoenergetic fast neutron fluence rates;
- 5.3 Comparison of measurements of radionuclide neutron source emission rates.

6 Other business; date of next meeting:

- 6.1 Retirement of the Chairman;
- 6.2 ETL;
- 6.3 Bibliography;
- 6.4 Exchange of information on work in progress at participants' laboratories;
- 6.5 Visit to the BIPM laboratories;
- 6.6 Date of next meeting.

Abstract

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation (CCRI) held its thirteenth meeting at the Pavillon de Breteuil, Sèvres, on 31 May and 1 June 1999. A final report on neutron measurements at the BIPM and a report on the completed comparison of 24.5 keV fluence measurements were presented. The process of deriving a reference value from these results was discussed in detail. This will be the first key comparison completed under the guidelines of the proposed Mutual Recognition Arrangement (MRA) among national metrology institutes. T.J. Quinn, the Director of the BIPM, discussed the evolving terms of the arrangement for establishing the degrees of equivalence of national measurement systems. Plans and suggestions for future comparisons were discussed, including those of measurements of quantities such as thermal neutron fluence rate, fast neutron fluence at several energies in the keV and MeV ranges, and neutron source emission rates. Finally there was an exchange of information on work in progress at the participants' laboratories.

1 OPENING OF THE MEETING; APPROVAL OF THE AGENDA; APPOINTMENT OF A RAPPORTEUR

Section III (Neutron measurements) of the Consultative Committee for Ionizing Radiation (CCRI) held its thirteenth meeting at the Pavillon de Breteuil, Sèvres, on 31 May and 1 June 1999.

The following were present: T. Bolognese (IPSN), D.M. Gilliam (NIST), H. Klein (PTB), K. Kudo (ETL), V.E. Lewis (Chairman of CCRI Section III, NPL), G. Moscati (President of the CCRI), A.J.M. Plompen (IRMM), T.J. Quinn (Director of the BIPM), N.D. Villevalde (VNIIM), J. Zoetelief (IRI).

Observers: A. Allisy (ICRU), Rong Chaofan (CIAE).

Attended all or part of the meeting: D.T. Burns, C. Thomas (BIPM).

The Director of the BIPM welcomed the participants of Section III and invited Section III to a joint session with Section II (Measurement of radionuclides) for his presentation on developments toward the signing of the MRA.

The Chairman of Section III welcomed its members and observers.

D.M. Gilliam accepted the task of rapporteur.

2 REPORT ON THE FIFTEENTH MEETING OF THE CCEMRI

The written report on the fifteenth meeting of the CCEMRI (now renamed the CCRI) had already been received by the members of Section III. Prof. G. Moscati, President of the CCRI, and the Chairman of Section III commented briefly that the new policy of convening the CCRI promptly following the meetings of the three Sections is in keeping with the more independent roles now played by the separate Sections and is more efficient in the use of the time of the members of the CCRI.

3 MUTUAL RECOGNITION ARRANGEMENT

In his welcoming remarks to Section III and in a joint session with Sections II and III, T.J. Quinn, the Director of the BIPM, discussed the evolving terms of the arrangement for establishing the degrees of equivalence of national metrology institutes and the role of the individual Sections and working groups of Consultative Committees in carrying out the key comparisons on which mutual recognition will be based.

4 COMPARISON OF MEASUREMENTS OF 24.5 keV FLUENCES

The Chairman summarized the main features of the comparison of measurements of 24.5 keV fluences, which involved the circulation of a set of three Bonner spheres with a common ^{3}He proportional counter detector. This comparison had been described in NPL Report CIRM 16. The exercise had been coordinated by the BIPM, first by V.D. Huynh and then by G. Ratel. Between measurements by the individual laboratories, the Bonner spheres had been returned to the BIPM for the ^{3}He detector to be checked using an arrangement comprising a polyethylene sphere and an ^{241}Am-Be source. A summary of the data produced in these checks was shown and discussed. There had been some problems with the instrumentation including the catastrophic failure of the original ^{3}He detector and a small, unexplained loss of sensitivity of its replacement.

The results of the comparison (published in the NPL report) were reviewed and considered to be consistent with the estimated uncertainties. Each of the three spheres had an associated set of sensitivity values measured by the participants. The unweighted means of each set were calculated and the participants' values were normalized to these. It was noted that the inclusion of the values of one participant, which were much lower than those of the other four, had a significant influence on the mean values. For each laboratory the means of the three normalized values were calculated in order to derive a reference value that would be used in evaluating degrees of equivalence.

The calculations were repeated using weighted means. The evaluator (V.E. Lewis) noted that the stated uncertainties were mostly around 9 % (at the 95 % confidence level), but were much higher for the participant with outlying results, who had experienced severe experimental difficulties, and were much lower for one other. This meant that the former had little influence on the weighted means whereas the latter had a large impact. This in turn influenced the agreement between the participants' values and the reference value for each Bonner sphere. The choice of whether to use weighted or unweighted means therefore influenced the laboratories' degree of equivalence with the reference value (although not the degrees of equivalence between pairs of laboratories).

In principle it was thought desirable to use the weighted means when calculating reference values and evaluating degrees of equivalence. It was agreed that the uncertainty budgets (which had been submitted to the evaluator but not circulated) should be analysed more rigorously. Correlations in the uncertainty components should be taken into account, but it was acknowledged that they were very small for this work and likely to have little effect. It was also agreed that the full measurement details required by the protocol would be demanded from those laboratories that had not submitted full reports.

The revised results would be sent to participants for their approval before incorporation into a paper to be submitted to *Metrologia*.

5 REVIEW OF PREVIOUS KEY COMPARISONS AND PLANS FOR FURTHER MEASUREMENT COMPARISONS

The Chairman presented a listing of the comparisons carried out previously by Section III in the proposed format of the key comparison database to be maintained by the BIPM. This listing comprehensively reflected the history of the existing comparisons of the quantities designated to be the subject of key comparisons. These had been approved at the previous meeting of Section III, in 1997, and were reaffirmed as being thermal neutron fluence rate, fast neutron fluence at recommended energies and radionuclide neutron source emission rate. The comparisons of measurements of neutron absorbed dose

were excluded because it was agreed that these were now of little relevance and no more were planned.

The Chairman's listing of the comparisons was reviewed and a few additions and corrections were made. The information to be included for each of these comparisons in the BIPM key comparison database will be limited to a brief listing of the measurement parameters and participants, along with citations of the published results. There will be no attempt to go back to these reports and try to extract reference values or degrees of equivalence.

It was agreed unanimously that a period of about ten years was appropriate for repeating the key comparisons for Section III in the future. Plans for repeating three key comparisons are already under way and are described below.

5.1 Comparison of measurements of thermal neutron fluence rates

A draft protocol for a new key comparison of thermal neutron fluence rates was presented by D.M. Gilliam. The transfer instruments for this comparison will be a set of ^{10}B ionization chambers and associated electronics supplied by the NIST. The problems anticipated with stability of the ^{10}B deposits will be managed by careful checks at the NIST before and after the measurements of each participant and by inclusion of special equipment in the transfer system to limit the exposure of the ^{10}B to humidity. Tentative expressions of interest in participation were expressed by the CIAE, the ETL, the IRMM, the NIST, the NPL, the PTB and the VNIIM.

A few changes and additions to the draft protocol were suggested. The meeting recommended that the draft be reviewed carefully with regard to conformity with the recommendations of Appendix F of the MRA (Guidelines for CIPM key comparisons). H. Klein suggested:

1) that the uncertainty budgets of each participant be published in a widely accessible journal;
2) that each participant verify the accuracy of the timing in the counter-timer module supplied by the NIST as operated in his or her own laboratory conditions; and
3) that the protocol should include guidance for connection of the amplifier signal to a local pulse-height analyzer for either 100 Ω or 50 Ω cables.

K. Kudo suggested that a well-fitting cadmium box be sent with the transfer instruments for checking the background. D.M. Gilliam agreed to distribute a revised protocol taking these suggestions into account by 1 August 1999. It

was hoped that the final version of this protocol would be accepted by all participants by 31 October 1999.

The NIST would first send the results of its own fluence rate measurements under the protocol to the BIPM and would then be ready to send the transfer instrument system out to other participants by January 2000. The NIST would act as both coordinator and pilot laboratory, with the record of the NIST results maintained by the BIPM to guarantee freedom of influence from the results of other participants subsequently received and analysed by the NIST. The CIAE and the NPL asked to be among the first to participate.

5.2 Comparisons of measurements of monoenergetic fast neutron fluence rates

H. Klein offered the monoenergetic fast neutron beam capabilities at the PTB for a new type of comparison of fluence measurements. The PTB would be prepared to provide monoenergetic beams at several different fast neutron energies running twenty-four hours per day over a period of about two weeks. All participants would bring their fluence measuring systems to the PTB to make measurements at as many of these energies as practicable. The accelerator would remain at each energy for about forty-eight hours before changing to the next energy. This new style of comparison should allow several of the previous comparisons that took place over periods of several years to be completed within a very short time.

Many different kinds of fluence measurements could be made using fission chambers, long counters, Bonner spheres, activation techniques, proportional counters, or other devices. The PTB would provide stands and mounting hardware to position the various detectors at about 1 metre from the accelerator target. Shadow cones would also be provided by the PTB for correction of scattered neutron contributions. The fluence rates available would be of the order of 10^2 to 10^3 neutrons cm^{-2} s^{-1}.

The PTB proposed nine energies: 144 keV, 250 keV, 565 keV, 1.2 MeV, 2.5 MeV, 5.0 MeV, 8.0 MeV, 14.8 MeV and 19.0 MeV. However, other members thought that this number would be too many and therefore 250 keV and 8.0 MeV were omitted. H. Klein agreed to distribute a questionnaire to Section III members on scheduling constraints and intentions for participation in the proposed comparisons. It was agreed that these should be returned to him by the end of August 1999. It was hoped to hold the measurement session at the PTB about the middle of 2000.

The efficiency of this new approach to comparisons would be extremely helpful given the goal of repeating the key comparisons every ten years. The alternative would be the circulation of perhaps several sets of transfer instrumentation to laboratories all over the world. From past experience, such comparisons were known to take much longer. Furthermore, no laboratory was prepared to organize further comparisons of this previous format.

5.3 Comparison of measurements of radionuclide neutron source emission rates

The Chairman reported that he had been informed by the VNIIM that there would be difficulties in using the Russian ^{244}Cm spontaneous fission source for this exercise as had been proposed at the previous meeting of Section III. The use of an ^{241}Am-Be source instead of or in parallel with the ^{244}Cm source was discussed. Such sources were readily available and widely used and calibrated. H. Klein offered the use of two PTB sources with strengths of about 37 GBq, yielding emission rates of about 2×10^6 s^{-1}. Both sources were of the standard Amersham International construction. One source could be used for the Section III exercise and the other for a EUROMET comparison that could be linked to the former. D.M. Gilliam offered the use of two transport containers.

The Chairman agreed to draft a protocol taking into account the guidelines of the anticipated MRA and based on the protocol for the previous comparison, which had been organized by the NPL. An independent evaluator would eventually be required, but the choice would be left open for the time being. As an interim measure, H. Klein would receive results because the PTB would not be a participant.

The participation was discussed at length. The CIAE, the NPL and the NIST were ready to participate and the ETL expected to be able to participate near the end of the comparison. It was anticipated that the KRISS and the VNIIM would also participate. The Chairman would contact the BNM-LPRI, the ENEA and the NIM; Prof. Moscati agreed to ascertain the situation for Brazil. It was thought that the BNM-LPRI, the CMI, the ENEA, the NPL and Slovakia would be involved in the EUROMET comparison. The Chairman would inform the laboratories of the situation regarding the Section III comparison and the offer of the PTB to provide sources for both exercises. In order to link the two, there would have to be participation in both by at least two laboratories.

The exercise would involve sequential measurements that could take two years or longer to complete. It was hoped that the comparison would be well under way by the time of the next meeting.

6 OTHER BUSINESS; DATE OF NEXT MEETING

6.1 Retirement of the Chairman

The Chairman announced that this would be his last meeting with Section III. Since he is to retire from the NPL shortly after the next meeting, the NPL would send someone else. He thanked the members for their support and wished the Section every success in years to come. The members of Section III joined in expressing their gratitude to Vic Lewis for his effective leadership and the spirit with which he guided the work of the Section. Dr Lewis had served as the Chairman for five meetings of the Section and for seven meetings altogether. He will continue to serve as Chairman until his successor is appointed. All joined in wishing him a long and happy retirement from the Section and from the NPL. The choice of a successor to Dr Lewis as Chairman of Section III would be considered by the CCRI.

6.2 ETL

K. Kudo announced that some reorganization of the metrology laboratories of Japan will take place. The Electrotechnical Laboratory (ETL) and two other institutes under the Ministry of International Trade and Industry of Japan will be combined to form a new national institute of metrology.

6.3 Bibliography

H. Klein endorsed the proposal for the compilation of bibliographies from participating laboratories in the BIPM website, but would prefer to see these updated every six months, rather than every two years.

6.4 Exchange of information on work in progress at participants' laboratories

A very interesting exchange of information took place. Brief summaries of work in progress at their laboratories were given by all members present.

6.5 Visit to the BIPM laboratories

An interesting visit to the BIPM laboratory for ionizing radiation measurements was arranged. Section III expressed its gratitude to the BIPM for arranging this visit and for the excellent organization of the meeting.

6.6 Date of next meeting

The date for the fourteenth meeting of Section III was discussed. Members felt that it would be desirable to meet next in 2001 in order to expedite the business of the Section in the best possible fashion and to remain in phase with the meetings of the CCRI and of Sections I and II.

D.M. Gilliam, Rapporteur
November 1999
revised September 2000

APPENDIX R(III) 1.
Working documents submitted to Section III of the CCRI at its 13th meeting

(see the list of documents on page 103)

LIST OF ACRONYMS USED IN THE PRESENT VOLUME

1 Acronyms for laboratories and committees

AAPM	American Association of Physicists in Medicine, College Park MD (United States)
ANSTO	Australian Nuclear Science and Technology Organisation, Menai (Australia)
APMP	Asia/Pacific Metrology Programme
APMP/TCRI	Asia/Pacific Metrology Programme, Technical Committee on Ionizing Radiation
ARL*	Australian Radiation Laboratory, Yallambie (Australia), see ARPANSA
ARPANSA	(ex ARL) Australian Radiation Protection and Nuclear Safety Agency, Victoria (Australia)
BEV	Bundesamt für Eich- und Vermessungswesen, Vienna (Austria)
BIPM	Bureau International des Poids et Mesures
BNM	Bureau National de Métrologie, Paris (France)
BNM-LCIE	Bureau National de Métrologie, Laboratoire Central des Industries Électriques, Fontenay-aux-Roses (France)
BNM-LNHB	(formerly the BNM-LPRI) Bureau National de Métrologie, Laboratoire National Henri Becquerel, Gif-sur-Yvette (France)
BNM-LPRI*	Bureau National de Métrologie, Laboratoire Primaire des Rayonnements Ionisants, Saclay (France), see BNM-LNHB
CCEMRI*	Consultative Committee for Standards of Ionizing Radiation, see CCRI
CCRI	(formerly the CCEMRI) Consultative Committee for Ionizing Radiation
CIAE	Chinese Institute of Atomic Energy, Beijing (China)
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Madrid (Spain)
CIPM	Comité International des Poids et Mesures

* Organizations marked with an asterisk either no longer exist or operate under a different acronym.

CMI	Český Metrologický Institut/Czech Metrological Institute, Prague (Czech Rep.)
COMECON	Council for Mutual Economic Assistance
ENEA-INMRI	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti, Rome (Italy)
ESTRO	European Society for Therapeutic Radiology and Oncology, Brussels (Belgium)
ETL	Electrotechnical Laboratory, Tsukuba (Japan)
EUROMET	European Collaboration in Measurement Standards
GUM	Glówny Urzad Miar/Central Office of Measures, Warsaw (Poland)
IAEA	International Atomic Energy Agency
ICRM	International Committee for Radionuclide Metrology
ICRU	International Commission on Radiation Units and Measurements
INMRI	see ENEA
IOMP	International Organization for Medical Physics
IRA	Institut de Radiophysique Appliquée, Lausanne (Switzerland)
IRD	see LNMRI
IRI-TNO	Institute of Applied Radiobiology and Immunology, Centre for Radiological Protection and Dosimetry, Rijswijk (The Netherlands), see TNO
IRK	Institut für Radiumforschung und Kernphysik, Vienna (Austria)
IRMM	Institute for Reference Materials and Measurements, European Commission
IRPA	International Radioprotection Association
ISO	International Organization for Standardization
JCRB	Joint Committee of the Regional Metrology Organizations and the BIPM
KRISS	Korea Research Institute of Standards and Science, Taejon (Rep. of Korea)
LCIE	Laboratoire Central des Industries Électriques, Fontenay-aux-Roses (France), see BNM-LCIE
LNHB	Laboratoire National Henri Becquerel, Gif-sur-Yvette (France), see BNM-LNHB
LNMRI/IRD	Laboratório Nacional de Metrologia das Radiaçoes Ionizantes, Instituto de Radioproteçao e Dosimetria, Rio de Janeiro (Brazil)

LPRI*	Laboratoire Primaire des Rayonnements Ionisants, Saclay (France), see BNM
Metas	(formerly the OFMET) Office Fédéral de Métrologie et d'Accréditation, Wabern (Switzerland)
NAC	National Accelerator Centre, Faure (South Africa)
NIM	National Institute of Metrology, Beijing (China)
NIST	National Institute of Standards and Technology, Gaithersburg (United States)
NMI	National Institute of Metrology
NMi-VSL	Nederlands Meetinstituut, Van Swinden Laboratorium, Delft (The Netherlands)
NPL	National Physical Laboratory, Teddington (United Kingdom)
NRC	National Research Council of Canada, Ottawa (Canada)
OFMET*	Office Fédéral de Métrologie, Wabern (Switzerland), see Metas
OMH	Országos Mérésügyi Hivatal, Budapest (Hungary)
PAHO	Pan American Health Organization, Washington DC (United States)
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig (Germany)
RC	Radioisotope Centre, Otwock (Poland)
SRPI	Swedish Radiation Protection Institute, Stockholm (Sweden)
SSI	see SRPI
TCRI	Technical Committee on Ionizing Radiation, see APMP/TCRI
TNO	TNO Medical Biological Laboratory, Rijswijk (The Netherlands)
VNIIM	D.I. Mendeleyev Institute for Metrology, St Petersburg (Russian Fed.)
WHO	World Health Organization

2 Acronyms for scientific terms

EGS4	Electron Gamma Showers Version 4
KCDB	BIPM Key Comparison Database
LS	Liquid Scintillation
SI	International System of Units
SIR	International Reference System for gamma-ray emitting nuclides
TDCR	Triple-to-Double Coincidence Ratio Technique
WAFAC	Wide-Angle Free-Air Chamber