Rapport du directeur sur l'activité et la gestion du Bureau international des poids et mesures (BIPM)

(1er janvier 2013 – 31 décembre 2013)

Director's Report on the Activity and Management of the International Bureau of Weights and Measures (BIPM)

(1 January 2013 – 31 December 2013)

Tome 14

Bureau international des poids et mesures

Bureau international des poids et mesures

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BIPM Director's Report 2013

This BIPM Director's Report describes the activity of the BIPM and is one of a set of three documents issued annually by the CIPM and the BIPM which collectively cover the formal reporting to Member States, the other two reports in the set being the:

- Report of the 102nd Meeting of the International Committee for Weights and Measures (June and October 2013), and the
- *Rapport annuel aux gouvernements des hautes parties contractantes sur la situation administrative et financière du Bureau international des poids et mesures 2013*.

Note on the use of the English text

To make its work more widely accessible the International Committee for Weights and Measures publishes an English version of these 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.

TABLE OF CONTENTS

MEMBER STATES AND ASSOCIATES OF THE GENERAL CONFERENCE

as of 31 December 2013

Member States

Argentina
Australia
Austria
Belgium
Brazil
Bulgaria
Canada
Chile
China
Colombia
Croatia
Czech Republic
Denmark
Dominican Republic
Egypt
Finland
France
Germany
Greece
Hungary
India
Indonesia
Iran (Islamic Republic of)
Iraq
Ireland
Israel
Italy
Japan
Kazakhstan
Kenya
Malaysia
Mexico
Netherlands
New Zealand
Norway
Pakistan
Poland
Portugal
Republic of Korea
Romania
Russian Federation
Saudi Arabia
Serbia
Singapore
Slovakia
South Africa
Spain
Sweden
Switzerland
Thailand
Tunisia
Turkey
United Kingdom of Great Britain and Northern Ireland
United States of America
Uruguay
Venezuela (Bolivarian Republic of)

Associates of the General Conference

Albania
Bangladesh
Belarus
Bolivia (Plurinational State of)
Bosnia and Herzegovina
Botswana
CARICOM
Chinese Taipei
Costa Rica
Cuba
Ecuador
Estonia
Former Yugoslav Republic of Macedonia
Georgia
Ghana
Hong Kong (China)
Jamaica
Latvia
Lithuania
Malta
Mauritius
Mongolia
Montenegro
Namibia
Oman
Panama
Paraguay
Peru
Philippines
Republic of Moldova
Seychelles
Slovenia
Sri Lanka
Syrian Arab Republic
Ukraine
Viet Nam
Zambia
Zimbabwe

Director's Report
on the Activity and Management
of the International Bureau
# of Weights and Measures

(1 January 2013 – 31 December 2013)

1. INTRODUCTION

1.1. General introduction and overview of 2013

My first year as Director of the BIPM in 2013 has been a year of change for the BIPM. Appropriately, it started with the development and publication of a revised statement of the Mission, Role and Objectives of the BIPM based on the original objectives set by the Metre Convention, but reinterpreted for the 21st Century. Subsequently, we have developed a new strategy for the BIPM and an associated consolidated planning process. Both of these have involved substantial contributions from the International Committee for Weights and Measures (CIPM) and consultations with all of our stakeholders.

An important contribution to the BIPM strategy has been from the strategies developed by each of the Consultative Committees of the CIPM (CCs). These have triggered a review of current activities within the CCs and their Working groups. The CCs are focusing once again on ensuring that proposed comparisons are truly "key" and as a consequence the growth in the number of CC Key Comparisons has been stabilized, and in some cases reduced. Reducing the number of Working Groups and reducing comparison participation will have the positive effect of reducing the workload for the national metrology institutes (NMIs).

These initiatives will bring many benefits including providing a transparent basis for the formulation of the BIPM work programme for 2016–2019.

We have also continued with the initiatives to streamline the production of our publications. In particular, we have eliminated duplication between publications and have implemented a policy of making publications available through our website immediately they become available. Hence we have avoided delays incurred during the translation and printing of publications.

The BIPM's administrative and support services were restructured during 2013. The former Finance, Administration and General Services Department was reorganized into two new units managed from within the Director's Office. At the same time a new General Services grouping was created which incorporates the BIPM Workshop and building maintenance together with responsibilities for safety, quality and the BIPM grounds. I also initiated the process of planning for a major refurbishment of the historic *Observatoire* building to create a unified suite of laboratories and offices for the scientific staff.

This has also been the first year of the new Programme of Work agreed at the 24th meeting of the General Conference on Weights and Measures (CGPM) for the period 2013 to 2015. Details of the BIPM's scientific work in 2013 can be found in section 2 of this report and in the supplements which are available on the BIPM website.

2. LABORATORY WORK AT THE BIPM

In order to carry out its mission of ensuring and promoting the global comparability of measurements, the BIPM operates laboratories in the fields of mass, time, electricity, ionizing radiation and chemistry. All of the laboratory work addresses one or more of the agreed objectives for the BIPM, which are:

– To establish and maintain appropriate reference standards for use as the basis of a limited number of key international comparisons at the highest level.

– To coordinate international comparisons of national measurement standards through the Consultative Committees of the CIPM; taking the role of coordinating laboratory for selected comparisons of the highest priority and undertaking the scientific work necessary to enable this to be done.

– To provide selected calibrations for Member States.

In the following sections, we provide some highlights of the work during 2013. Extended reports of the work of each department are available at http://www.bipm.org/en/publications/directors_report/.

2.1. Mass

In December 2013 the Mass Department started a campaign of *Extraordinary Calibrations* against the IPK. This campaign will meet one of the prerequisites for the redefinition of the kilogram requested by the Consultative Committee for Mass and Related Quantities (CCM). It will enable the mass standards used in the watt balance and X-ray crystal density (XRCD) experiments, which will contribute to fixing the numerical value of the Planck constant, and the BIPM reference and working standards, to be compared as directly as possible with the international prototype of the kilogram (IPK). In the first phase, the BIPM working standards will be calibrated with respect to the IPK. Subsequently, the effect of cleaning and washing the six '*temoins*' ('witnesses') and finally the IPK itself will be studied. In the second phase, which will start in the second half of 2014, transfer standards from NMIs involved in determinations of the Planck constant and the Avogadro constant will be calibrated. This work has been planned in discussion with a number of members of the CCM meeting as a support group chaired by the Director of the BIPM.

Significant progress has been made with the BIPM Ensemble of Reference Mass Standards (ERMS) in 2013. Experimental improvements have been implemented in each of the three storage networks (gas, vacuum and air). As an example, a new vacuum network has been set up and is now operational and specific mass containers have been designed and fabricated to be compatible with the vacuum weighing facilities available in the Mass Department.

A new project related to surface analysis of the ERMS mass standards has started. Inside each container that will accommodate one of the standards, six samples of 1.5 mm thickness and of the same material as the standard will be stored. The samples will undergo periodic surface analysis which will be carried out through partnerships with selected NMIs.

A successful collaboration between the BIPM and the Laboratoire Commun de Metrologie (LCM) LNE-CNAM, France, began in 2013 to measure the surface roughness of all the mass standards and two discs of each stack from the BIPM Ensemble. The collaboration will also measure the surface roughness of many of the samples. Surface roughness is a critical parameter which influences surface contamination and consequently mass changes. By the end of 2013 the LCM LNE-CNAM had made measurements on six 1 kg standards, two discs of one stack and eight samples. This collaboration will continue in 2014.

The BIPM watt balance was transferred to a new dedicated laboratory in early 2013. The new location provides better vibration isolation, improved temperature stability and enough space for a vacuum enclosure. In addition some experimental improvements such as a reduction of the influence of polarization and frequency mixing between the interferometer arms and a mathematical treatment of the effects of coil acceleration on the force measured by the weighing cell have been carried out. As a consequence, the standard deviation of measurements of the Planck constant in air was reduced from 1.4 parts in 10^6 to about 5 parts in 10^7.

The definitive magnetic circuit for the watt balance has been fabricated and assembled. It is based on an original BIPM design which has recently been applied to the construction of magnets for several other watt balances. Most of the parts were pre-machined by the BIPM workshop. Fabrication of the remaining components and the ultra-high precision machining of all parts has been undertaken by a company in the USA. Assembly was carried out at the BIPM with micrometre accuracy. The magnet has now been installed in the vacuum chamber of the watt balance. This is the first step in the assembly of a new version of the BIPM watt balance which has several new components, the most important of which is a device based on piezo-elements for the accurate control of the coil position and angle.

The Mass Department has calibrated six platinum-iridium prototypes and eleven stainless steel mass standards for Member States as part of its ongoing work programme. One prototype was characterized for its vacuum-to-air transfer behaviour and several new prototypes are being fabricated. Since June 2011, the Mass Department has organized a CCM comparison CCM.M-K4 of stainless steel mass standards with 16 NMIs. This comparison is now in the Draft A stage.

2.2. Time

BIPM *Circular T* is published monthly, giving traceability to the SI second via Coordinated Universal Time (UTC) to its local realizations in national laboratories. It represents the only key comparison on time CCTF-K001.UTC. It is the most frequent key comparison, with one evaluation of the key comparison reference value UTC and the degrees of equivalence [*UTC* - *UTC*(*k*)] every five days for 73 participants at the end of 2013. These participants together contribute data from more than 400 atomic clocks. The BIPM received full responsibility for the calculation and publication of results from the Consultative Committee for Time and Frequency (CCTF).

Nine primary frequency standards and one secondary representation of the second contributed to International Atomic Time (TAI) in 2013, with an average of three to four caesium fountains reporting measurements each month. The frequency stability of TAI is estimated to be 3 parts in 10^{16} for averaging times of one month, and its frequency accuracy is in the low 10^{-16}. A long-interval estimation of the stability of TAI indicates that it will decrease to 1.8 parts in 10^{16} over the next few years. Additionally, the procedure for including secondary frequency standard data in the accuracy algorithm of TAI was developed in the Time Department and since July 2013 the rubidium secondary standard from LNE-SYRTE, France, has been used for assessing the frequency of TAI.

Observations of Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS) satellites together with the Two-Way Satellite Time and Frequency Transfer (TWSTFT) technique have been used regularly in the calculation of TAI. Combined links are used regularly in the calculation; at the end of 2013 the combinations GPS/GLONASS and TW/GPS PPP serve to calculate 28 % of the links in TAI. The GPS Precise Positioning Technique (GPS PPP) alone or in combination with TWSTFT are in use for TAI clock comparisons in 55 % of the links, where the statistical uncertainty of time transfer is well below the nanosecond; the best value is 0.3 ns for 46 % of the time links.

There were several major achievements in the Time Department in 2013. Revision of the algorithm for the calculation of TAI/UTC was completed, studies on a new clock weighting procedure concluded based on the principle that a good clock is a predictable clock, rather than a stable clock as in the current procedure. A change in the strategy for fixing the upper limit of the weight has been identified. The consequence is a better distribution among the clock weights, with a reduction of the predominance of the caesium clocks and a 40 % increase of the H-masers at the maximum weight. Both, short- and long-term stability of TAI will improve by 20 %. The new algorithm will officially come into use at the beginning of 2014.

After the successful completion of a pilot experiment on the calculation of a rapid UTC (UTCr), the CCTF has approved a final report which demonstrated that UTCr reached the expected quality, providing a weekly solution that was consistently better than ±2 ns peak to peak with the final UTC published in *Circular T*. This publication impacts on the quality of the representations of UTC in national laboratories, and on the steering of the Global Navigation Satellite Systems times to UTC.

Development of optical fibre links has begun between several laboratories contributing to the computation of UTC, and a few are already computed on a regular basis. The Time Department conducted an experiment on the fibre link between representations of UTC in Poland with the newly developed BIPM calibration system. This exercise demonstrated excellent agreement between the GPS PPP link and the optical fibre link at the level of the GPS PPP uncertainty. The optical fibre link can also be used to assess the calibration of a "traditional" UTC link as a result of the small (hundred picosecond) and stable calibration uncertainty; the experiment validated the BIPM GNSS calibrating system with uB ~200 ps. In the future, 100 ps uncertainty could be attainable with optical fibre time links for UTC.

International coordination is a major activity in the Time Department. A workshop which was jointly organized by the BIPM and the International Telecommunication Union (ITU) was held in Geneva, Switzerland, on 19-20 September 2013. The workshop was in preparation for the World Radiocommunication Conference 2015, where a decision is expected on the redefinition of UTC without leap second adjustments. The meeting provided a unique opportunity to obtain input from most of the relevant communities, among them the four GNSS providers, the telecommunications sector, time stamping authorities, astronomers and geodesists.

2.3. Electricity

The Electricity Department work programme in 2013 focused on the comparison programme to validate national primary standards for fundamental electrical quantities (voltage, resistance and capacitance), conducting calibrations for the same quantities for the NMIs of Member States, and support for the BIPM watt balance.

Dr Stéphane Solve from the Electricity Department worked as a guest researcher with the Quantum Voltage Project group of the NIST, USA, from July 2012 until July 2013. During this time he was trained in the use of superconductor-normal metal-superconductor (SNS) arrays in the field of synthesis of ac voltages and their applications, in preparation for a future BIPM comparison in this field. A travelling programmable Josephson Voltage Standard (PJVS) with compact electronics has been designed for the BIPM under a cooperative research and development agreement. This new system has been compared against a second PJVS system and in this work the smallest uncertainty achieved to date when comparing PJVS standards has been obtained. The difference was found to be 2.6 parts in 10^{11}, with an uncertainty of 3.4 parts in 10^{11}. Several error sources have been investigated during the course of this work. The dominant effect is due to leakage resistances, which allow small currents to flow from components of the measurement circuit directly to ground. The effect was studied by using a technique which had

previously been developed and proven by the BIPM. This effect can lead to systematic errors of the level of 1 nV at 10 V, that is 1 part in 10^{10}. The work also demonstrated that trapped magnetic flux can lead to small systematic and reproducible voltage errors, which are difficult to detect. Details are described in a joint BIPM-NIST publication*.

The Consultative Committee for Electricity and Magnetism (CCEM) has requested the BIPM to resume the BIPM.EM-K12 on-site comparison of quantum Hall resistance standards. In November 2013 a team from the BIPM carried out the first of a new series of on-site comparisons at the PTB, Germany. This comparison tested the equipment and techniques used to realize the ohm from the quantum Hall effect (QHE). The BIPM and the PTB measured the same 100 Ω resistor with completely independent measurement systems and QHE references, and obtained agreement to better than 1 nΩ/Ω. Subsequently, the scaling of resistance values across 4 decades was tested by measuring 1 Ω and 10 kΩ standards. Similarly, excellent agreement was found at 10 kΩ, whereas at 1 Ω the uncertainty of the comparison was several times larger due to non-ideal properties of the 1 Ω reference resistor, which is a known problem for low value standards. The results at all values are substantially better than could be obtained by exchanging travelling standards, where the relative uncertainties are at best 1 or 2 parts in 10^8.

Advances in cryogenic current comparator (CCC) bridge technology since the last series of on-site QHE comparisons (5 were carried out in the period 1993-1997) have allowed a better investigation of limiting factors, in particular the problems due to Peltier heating in 1 Ω standards. Beyond the main comparison result, bringing two systems together in the same laboratory has provided useful information to both laboratories and will contribute to the optimization of the protocol for future on-site comparisons. After this successful first exercise at the PTB, there will now be a series of comparisons at NMIs around the world over the next few years.

2.4. Ionizing radiation

The Ionizing Radiation Department has coordinated the sixth comparison in the series BIPM.RI(I)-K6 for absorbed dose to water in high-energy photon beams, with the NPL in the 6 MV, 10 MV and 25 MV beams of the Elekta accelerator, from 16 September to 4 October and 18 to 22 November 2013. Reports of two previous comparisons in the series were published in 2013, with the NIST and the LNE-LNHB, France. The report of the comparison carried out at the ARPANSA, Australia, in 2012 is close to completion. The method for establishing degrees of equivalence for the series BIPM.RI(I)-K6, based on the BIPM calorimetric determination in terms of the Tissue Phantom Ratio ($TPR_{20,10}$) was agreed at the meeting of the Consultative Committee for Ionizing Radiation (CCRI) in May 2013 and was published†. The four comparison results that have been registered in the BIPM key comparison database (KCDB) so far agree to better than 0.8 % within the expanded uncertainties (typically 1.2 %, $k = 2$).

The project to develop an absorbed-dose standard for medium-energy x-rays has continued. It is based on the existing free-air chamber standard using a set of waterproof transfer standards of different wall materials and shape. Initial problems with leakage currents have been overcome by using a conductive graphite coating. The experiment to test the photon interaction cross-section data (μ-values) used by the simulation code PENELOPE continued with improved calculations in the context of absorbed-dose for medium energy x-rays. It is worth noting that the calculated ratios $\mu_{a,c}$ and $\mu_{a,w}$ agree with their measured values at the level of around 5 parts in 10^3 (the statistical uncertainty), except at 100 kV where a difference of 1 to 2 parts in 10^2 is observed.

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* Solve S., Rüfenacht A., Burroughs C.J. and Benz S.P., Direct comparison of two NIST PJVS systems at 10 V. *Metrologia*, 2013, **50**, 441.

† Picard S., Burns D.T., and Los Arcos J.M., Establishment of degrees of equivalence of national primary standards for absorbed dose to water in accelerator photon beams, *Metrologia*, 2013, **50,** *Tech. Suppl.* 06016.

A paper has been submitted to *Physics in Medicine and Biology* on the W_a value for accelerator photon beams, which incorporates data from the BIPM.RI(I)-K6 comparisons, Monte Carlo calculations and cavity volume measurements of ionization chambers constructed at the BIPM. The paper concludes that there is no evidence for an energy variation for W_a, an important finding that will reduce the uncertainty of high-energy clinical reference dosimetry. A by-product of this work is a new determination of the I_c-value for graphite. These results will be incorporated into a report on Key Data being prepared by the International Commission on Radiation Units and Measurements (ICRU). Four comparisons, 42 calibrations of national secondary standards and eleven comparison reports were produced, all of which were underpinned by a significant effort in equipment calibration and maintenance.

During 2013, as part of the radionuclide measurements programme, the BIPM received seven ampoules filled with seven different radionuclides from four laboratories i.e. one ampoule each containing ^{57}Co (POLATOM), ^{59}Fe (LNE-LNHB), ^{109}Cd (LNE-LNHB), ^{137}Cs (POLATOM), ^{166m}Ho (PTB), ^{177}Lu (IFIN-HH) and ^{222}Rn (LNE-LNHB). All the submissions had been made to generate equivalence values in the associated ongoing BIPM key comparison BIPM.RI(II)-K1. Measurements of ^{222}Rn, a radioactive gas with a short half-life ($T_{1/2}$ = 3.8235 d, u = 0.0003 d), were repeated to try to remove a systematic bias detected in the activity determination of the gas. The analysis is ongoing. Updated reports of three comparisons were published in the *Metrologia Technical Supplement* covering ^{64}Cu[‡], ^{134}Cs[§] and ^{137}Cs[**] including the linked COOMET.RI(II)-K2.Cs-137 comparison.

For short-lived radionuclides, the BIPM report[††] describing the SIR Transfer Instrument (SIRTI) in detail and reporting the tests made during its development has been finalized and published. The BIPM.RI(II)-K4.Tc-99m ($T_{1/2}$ = 6.0 h) key comparison using the SIRTI is running at a rate of two comparisons per year: the LNMRI-IRD, Brazil, and the IFIN-HH, Romania, participated in 2013. Results of the comparisons in China, Argentina and Brazil have been published. The VNIIM, Russian Federation, is the next scheduled participant. The SIRTI has remained very stable since 2007 even though it is regularly transported around the world, showing a relative standard deviation of 6×10^{-5} for the counting rate of the ^{94}Nb reference source.

The extension of the SIRTI for measuring ^{18}F ($T_{1/2}$ = 1.8 h) is in development. Stability and reproducibility tests were carried out successfully and Monte Carlo simulations of the SIRTI response to ^{18}F agree with preliminary measurements within 4×10^{-3}. A trial comparison of ^{18}F at a NMI in Europe which has already participated in the international reference system (SIR) will be organized for the ENEA-INMRI (Italy), NIST (USA), NIM (China), ANSTO (Australia), CNEA (Argentina), IFIN-HH (Romania), LNMRI/IRD (Brazil) and the VNIIM (Russian Federation).

The trial exercise for the extension of the SIR to the measurement of pure beta emitters has continued. Results obtained for the submissions of the eight participating laboratories (ENEA (Italy), IRMM (EU), LNE-LNHB (France), NIST (USA), NMISA (South Africa), NPL (UK), PTB (Germany) and POLATOM (Poland)) with the BIPM Triple-to-Double Coincidence Ratio Technique (TDCR) system have been evaluated and compared with those obtained with the same technique at the LNE-LNHB. The results of these measurements were presented together with those obtained using the universal efficiency curves (UEC) during the CCRI(II) meeting held at the BIPM in May 2013 and at the ICRM 2013

[‡] Michotte C., *et. al*., Update of the BIPM comparison BIPM.RI(II)-K1.Cu-64 of activity measurements of the radionuclide ^{64}Cu to include the 2009 results of the CMI–IIR (Czech Rep.) and the NPL (UK), the 2010 result of the LNE–LNHB (France) and the 2011 result of the ENEA–INMRI (Italy). *Metrologia*, 2013, **50**, 06021.

[§] Michotte C., *et. al*., Update of the BIPM comparison BIPM.RI(II)-K1.Cs-134 of activity measurements of the radionuclide ^{134}Cs to include the 2008 results of the BEV (Austria), the 2009 result of the IRA (Switzerland) and the 2010 results of the NMISA (South Africa). *Metrologia*, 2013, **50**, 06009.

[**] Michotte C., *et. al*., Update of the BIPM comparison BIPM.RI(II)-K1.Cs-137 of activity measurements of the radionuclide ^{137}Cs to include the 2007 results of the VNIIM (Russia), the 2009 result of the IFIN-HH (Romania), the 2010 result of the NMISA (South Africa) and the 2011 result of the BEV (Austria). *Metrologia*, 2013, **50**, 06014.

[††] Michotte C., Nonis M., Bobin C., Altzizoglou T. and Sibbens G., The SIRTI: a new tool developed at the BIPM for comparing activity measurements of short-lived radionuclides world-wide. Rapport BIPM-2013/02, 2013, 23pp.

Conference in Antwerp, Belgium. A larger scale exercise was approved at the CCRI(II) in May 2013 that will cover ^{3}H, ^{14}C, ^{55}Fe and ^{63}Ni, with 19 NMIs having expressed an interest in participating.

2.5. Chemistry

The core areas of laboratory activity for the Chemistry Department are: international comparisons and equivalence of gas standards for air quality and climate change monitoring; and the international comparison programme on primary organic calibrators.

In the field of Gas Metrology, the BIPM has continued to coordinate comparisons of standards for greenhouse gases and air quality monitoring. In the area of greenhouse gases and their precursors, measurements for CCQM-K82 on methane at ambient levels were completed, and the Draft A report presented to the Consultative Committee for Amount of Substance: Metrology in Chemistry (CCQM) Working Group on Gas Analysis (GAWG). The results show an important improvement compared to a similar exercise organized in 2003, with the standard deviation of submitted results reduced by more than a factor of ten, reaching a value lower than 2 nmol mol^{-1}, equivalent to the Data Quality Objectives of the Global Atmosphere Watch (GAW) programme run by the World Meteorological Organization (WMO).

Preparatory work for the coordination of CCQM-K90 on formaldehyde (HCHO) in nitrogen standards continued, with successful completion of stability and purity tests performed during 2013, and the standards to be used for the comparison in 2014 are in preparation. Of the two sets of standards tested, which differed in preparation procedure and cylinder surface treatment, the set that was considered suitable demonstrated a linear loss of formaldehyde concentration of less than 0.2 % per month, while the other set showed increases of up to 2 % per month.

The BIPM and the International Atomic Energy Agency (IAEA) organized a workshop, which was hosted by the VSL, the Netherlands, on 4 June 2013. Its aim was to understand the current status of CO_2 and CH_4 isotope ratio standards and their importance for accurate concentration measurements of these important greenhouse gases. The conclusions of the workshop were presented at the 30th meeting of the CCQM-GAWG (November 2013), and the technical proposals for a key comparison (CCQM-K120) on CO_2 in air standards, to be coordinated by the BIPM and the NIST, were accepted. Initial work to develop measurement methods at the BIPM and validation standards for the comparison has started.

In the area of air quality gas standards, the ongoing Surface Ozone reference standard comparison (BIPM.QM-K1) has continued with five laboratories participating in 2013. The WMO guidelines[‡‡] for continuous measurements of ozone in the troposphere were published in 2013 and now include guidance on traceability with references to the BIPM.QM-K1 comparison. Work on new ozone absorption cross-section measurements is nearing completion with the assistance of a visiting scientist from the KRISS, Republic of Korea, for three months in 2013. The final report of the CCQM-P110.B2 pilot study for nitrogen dioxide standards has been published, and a paper describing accurate FTIR measurements of NO_2 and nitric acid by calibrations with synthetic spectra was published in *Applied Spectroscopy*[§§]. A relative uncertainty of 3.4 % for the measurements of NO_2 concentrations was demonstrated with this method and attributed mainly to the uncertainty in the line strength values (HITRAN 2004) and the knowledge of the optical path length of the FTIR gas cell, to be compared with a 0.4 % relative uncertainty when the FTIR was calibrated with standard gas mixtures.

The BIPM's organic programme forms an essential part of the CCQM Working Group on Organic Analysis (OAWG) strategy for Core Competency comparisons, and a paper describing the

[‡‡] Galbally I.E., *et al*., Guidelines for continuous measurements of ozone in the troposphere, GAW Report No. 209, 2013, 76 pp.

[§§] Flores E., Viallon J., Moussay P. and Wielgosz R.I., Accurate Fourier Transform Infrared (FT-IR) Spectroscopy Measurements of Nitrogen Dioxide and Nitric Acid Calibrated with Synthetic Spectra, *Appl. Spectrosc.*, 2013, **67**(10), 1171-1178.

implementation at the BIPM of the mass balance method for determining the mass fraction of the main component of a high purity organic material was published in *Analytical Chemistry*[***]. The final report of the CCQM-K55.c [(L)-Valine purity] key comparison and the parallel CCQM-P117.c pilot study are in preparation following approval of the key comparison reference value (KCRV). Thirty submissions were received from twenty five participating institutes which used either mass balance or quantitative nuclear magnetic resonance (QNMR) approaches, or the combination of data from both approaches, to assign the valine content of the material. The KCRV for the valine content is 992 mg/g with an associated standard uncertainty of 0.6 mg/g. Preparative work on samples for CCQM-K55.d [Folic acid purity] has started, with homogeneity and stability measurements under way. The aim is to establish the suitability of the material for the comparison by demonstrating that the between unit relative homogeneity and stability of impurities present in the candidate material is below 2 % and 1 % respectively for any component present at levels above 2 mg/g. Dependent on the successful outcome of these studies, it is planned that a key comparison and a parallel pilot study will start towards the end of 2014. Activities in large organic molecule purity have made substantial progress with the completion of measurements on pure Angiotensin I, as part of a BIPM-NIST collaboration in preparation for future key comparisons in the area, and with a paper on the methods developed published in *Analytical and Bioanalytical Chemistry*[†††]. Work on purity studies of insulin is also nearing completion, and the first CCQM key comparison on peptide purity (CCQM-K115) will be coordinated by the BIPM in collaboration with the NIM, China. Dr Ming Li from the NIM has joined the BIPM as a visiting scientist to work on the method development and study material characterization, in preparation for this key comparison.

For information about the Joint Committee for Traceability in Laboratory Medicine (JCTLM) see §4.3.2.

2.6. Comparisons

During 2013, there were a total of 27 comparisons coordinated by the BIPM involving 170 participations.

2.6.1. Mass

Comparison	Description	No. of NMI Participations
CCM.M-K4	Comparison of 1 kg stainless steel mass standards	16

2.6.2. Time

The Time Department pilots the key comparison CCTF-K001.UTC, published through the monthly *Circular T*. In 2013, 12 key comparisons (one each month) were carried out with 73 participants since November.

Comparison	Description	No. of NMI Participations
CCTF-K001.UTC	Calculation of the reference time scale UTC	73

[***] Westwood S., Josephs R., Choteau T., Daireaux A., Wielgosz R., Mass Balance Method for the SI Value Assignment of the Purity of Organic Compounds, *Anal. Chem*., 2013, **85**(6), 3118-3126.

[†††] Stoppacher N., Josephs R.D., Daireaux A., Choteau T., Westwood S.W., Wielgosz R.I., Impurity identification and determination for the peptide hormone angiotensin I by liquid chromatography-high-resolution tandem mass spectrometry and the metrological impact on value assignments by amino acid analysis, *Anal. Bioanal. Chem*., 2013, **405**(25), 8039–8051.

2.6.3. Electricity

Comparison	**Description**	**No. of NMI Participations**
BIPM.EM-K10	DC voltage, Josephson standards: (a) 1.018 V; (b) 10 V	1
BIPM.EM-K11	DC voltage, Zener diode: (a) 1.018 V; (b) 10 V	3
BIPM.EM-K12	Quantum Hall resistance standards and their scaling to other resistance values	1
BIPM.EM-K13	Comparison of resistance standards: (a) 1 ; (b) 10 k	4
BIPM.EM-K14	Comparison of capacitors: (a) 10 pF; (b) 100 pF	0
Total		**9**

2.6.4. Ionizing Radiation

The Ionizing Radiation Department undertook 13 bilateral ongoing comparisons in 2013.

Comparison	**Description**	**No. of NMI Participations**
BIPM.RI(I)-K1	Measurement of air kerma for Co-60 gamma-rays	1
BIPM.RI(I)-K4	Measurement of absorbed dose to water for Co-60 gamma-rays	2
BIPM.RI(I)-K6	Measurement of absorbed dose to water for high-energy beams	1 (off-site, NPL)
BIPM.RI(II)-K1.Co-57	Activity of radionuclides	1
BIPM.RI(II)-K1.Fe-59	Activity of radionuclides	1
BIPM.RI(II)-K1.Cd-109	Activity of radionuclides	1
BIPM.RI(II)-K1.Cs-137	Activity of radionuclides	1
BIPM.RI(II)-K1.Ho-166m	Activity of radionuclides	1
BIPM.RI(II)-K1.Lu-177	Activity of radionuclides	1
BIPM.RI(II)-K1.Rn-222	Activity of radionuclides	1
BIPM.RI(II)-K4.Tc-99m	Activity of radionuclides using the SIRTI	2 (off-site, LNMRI and IFIN-HH)
Total		**13**

2.6.5. Chemistry

In 2013 the Chemistry Department worked on three key comparisons and two pilot studies (all coordinated by the BIPM). For clarity these have been divided into those for which measurements were completed in 2013, and those that are in the reporting phase.

The Chemistry Department also undertook preparatory/validation work for four more comparisons which are planned for 2014/2015.

BIPM coordinated comparisons for which measurements were performed in 2013:

Comparison	**Description**	**Activity in 2013**	**No. of NMI participations**
BIPM.QM-K1	Ozone ambient level	Measurements completed and reports published	5
CCQM-K82	Methane in air (ambient)	Measurements completed Draft B report in preparation	16
Total			**21**

BIPM coordinated comparisons which are in reporting phase in 2013:

Comparison	**Description**	**Activity in 2013**	**No. of NMI participations**
CCQM-K55.c	Purity analysis series: L-Valine	KCRV agreed and Final Reports in Preparation	19
CCQM-P117c			10
CCQM-P110-B2	Nitrogen dioxide 10 µmol/mol: spectroscopic study	Published in *Metrologia Technical Supplement*	9
Total			**38**

BIPM coordinated comparisons for which preparatory/validation work has started:

Comparison	**Description**	**Activity in 2013**	**No. of NMI participations**
CCQM-K90	Formaldehyde in nitrogen	Stability studies of transfer standards	
CCQM-K55.d	Purity analysis series: Folic Acid	Homogeneity and stability measurements on material under way	
CCQM-K115	C-peptide purity	Method development under way	
CCQM-K120	CO_2 in air	Validation standards and facilities under development	

2.7. Calibrations

A total of 77 Certificates and 4 Study Notes were issued in 2013. A complete list of certificates is provided in Appendix 2.

3. THE CIPM MRA

3.1. New signatories to the CIPM MRA

The following institutions signed the CIPM MRA during 2013:

- Instituto Nacional de Metrología de Colombia (INM (CO)) on 15 May 2013
- Mongolian Agency for Standardization and Metrology (MASM) on 23 October 2013.

3.2. The BIPM key comparison database, KCDB

Bi-annual reports on the KCDB are available on the BIPM website at http://www.bipm.org/jsp/en/ViewKCDBReport.jsp. Readers are encouraged to consult these documents for detailed information about publication of key and supplementary comparisons and of approved sets of CMCs in the KCDB.

3.2.1. Content of the KCDB

3.2.1.1. Key and supplementary comparisons

On 11 December 2013, the key and supplementary comparisons database covered 864 key comparisons (86 from the BIPM, 427 from the CCs, and 351 from Regional Metrology Organizations (RMOs)) and 374 supplementary comparisons. A total of 45 new key comparisons and 46 new supplementary comparisons were registered during 2013, which is a similar rate to 2012.

Updated graphs illustrating participation in key and supplementary comparisons were made available on the statistics page of the KCDB on 18 November 2013.

On 11 December 2013, of the 864 key comparisons registered:

- 88 corresponded to exercises carried out prior to the entry into force of the CIPM MRA, and which therefore will never have results published in the KCDB; they have been "Approved for provisional equivalence".
- 77 of the 86 ongoing BIPM key comparisons had results published in the KCDB.
- A further 436 CC and RMO key comparisons had their final reports approved and were posted on the KCDB website, with corresponding tables of numbers and graphs entered in the database.

A total of 2 120 graphs of equivalence were displayed in the KCDB on 11 December 2013.

The results of 193 RMO key comparisons (1 conducted by AFRIMETS, 66 by APMP, 26 by COOMET, 82 by EURAMET, and 18 by SIM) were published in the KCDB, and linkage had also been carried out for 57 bilateral key comparisons subsequent to full-scale CC key comparisons; their results are included

in the appropriate graphs of equivalence. There are currently a dozen examples in the KCDB of seven or eight (there is even one case of nine) key comparisons that are linked together, demonstrating the success of the system.

Final reports for 209 of the 374 supplementary comparisons registered in the KCDB had been posted as of 11 December 2013.

Altogether 65 % of the comparisons registered in the KCDB are complete. The final reports have been posted in the KCDB, and are generally published in the *Metrologia Technical Supplement*. This percentage has been stable for several years.

3.2.1.2. Calibration and Measurement Capabilities – CMCs

On 11 December 2013, the KCDB included a total of 24 473 CMCs: 14 901 in General Physics, 3 956 in Ionizing Radiation, and 5 616 in Chemistry. The total number of CMCs has been reduced by about 1 000 when compared to the same period in 2012. This is the first decrease in the number of CMCs in eight years, even though approximately 600 new CMCs were approved and published during the last 12 months. This reduction is attributed to rationalization of EURAMET's CMCs in Electricity and Magnetism (EM).

The CCEM at its meeting in March 2013 strongly encouraged the NMIs and the RMOs to make their best possible effort towards concatenating diverse CMCs that cover the same quantity over different ranges of the measurand, but which use different methods or instruments, to create one (or very few) CMC(s) for each "sub-sub-category" of the Classification of Services in EM. EURAMET carried out this process and drew up tables of uncertainties describing individual CMCs that have a broad scope.

The EURAMET CMCs were published in the KCDB on 13 August 2013 after re-arrangement and re-formatting according to the CCEM guidance. As a result:

- The number of CMCs in EM from EURAMET has been approximately halved (3 435 to 1 821).
- The KCDB thus "lost" more than 1 600 CMCs (6.7 % of the total) in EM.
- About one third of the EURAMET CMCs in EM are now described using tables of uncertainties. This gives a total of 650 such tables, which include roughly 26 000 individual values of uncertainties.

To conclude, files of CMCs in EM from EURAMET are now easier to handle, review and publish. In addition, the users of the KCDB have access to more detailed information, but concatenated into clearer tables, which are easy to compare.

The first sets of CMCs declared by the institutes of Albania (7 CMCs in the field of Mass Standards), of The Former Yugoslav Republic of Macedonia (6 CMCs in the field of Fluid Flow) and of the Republic of Moldova (40 CMCs in the field of Thermometry) were posted in the KCDB on 5 April 2013, 2 July 2013 and 26 September 2013, respectively.

As at 11 December 2013 all of the Associates which participate in the CIPM MRA have at least one of their metrology institutes listed as a participant in a key or a supplementary comparison, whereas only 19 of the 38 Associates currently have CMCs published in the KCDB.

As at 11 December 2013, 216 CMCs were temporarily removed from the KCDB, a number that is considered small compared to the total number of CMCs in the KCDB.

Details of the number of CMCs currently published in the KCDB, by country and by metrology area, and the situation regarding greyed-out CMCs, are available in real-time from the statistics page of the KCDB. An Excel file which records the history of CMC publications (including greying-out and re-instatement)

is available, in real-time, on a restricted-access section of the JCRB CMC website. Following a request by the JCRB at its 24th meeting, the dates of greying-out of CMCs are included in this file.

3.2.2. Visits to the KCDB website

The log-on statistics for 2013 indicated that the average number of monthly visits stood at 10 300, and the average number of KCDB web pages opened each month was 100 000. This compares to 9 200 and 124 000 during 2012 respectively.

Following a recommendation by the JCRB at its 31st meeting in September 2013, an investigation has started on how to obtain information about visitors to the KCDB. The proposed survey (limited to a period of two to three months at the beginning of 2014) will use a pop-up window which will allow individual visitors to supply information about themselves.

3.2.3. The KCDB system

The back-office system used for creating the HTML pages of results of key comparisons had been in operation since 2000 and functioned correctly under Microsoft IE only. It became obsolete when Version 10 of IE was released. The external company responsible for maintenance of the programming of the KCDB system (under contract with the BIPM) has developed a new and more flexible tool, based on open-source software and which is able to operate with the most recent versions of internet browsers.

3.3. Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB)

Two meetings of the JCRB and a workshop on 'Best Practices in CMC Reviews' were held in 2013:

- The 30th meeting of the JCRB was held at the BIPM on 19 to 20 March 2013;
- The 31st meeting of the JCRB was held in Beijing, China, on 18 to 19 September 2013;
- The workshop on 'Best Practices in CMC Reviews' was held at the BIPM on 18 to 19 March 2013.

The Workshop on 'Best Practices in CMC Reviews' was very successful. Each RMO and CC had prepared and circulated a paper which they presented at the workshop detailing their views on improving the efficiency of inter-regional CMC reviews. This was supplemented by presentations from a number of CC and RMO representatives and collectively formed the input for the discussions. The summary outcome was discussed immediately at the 30th JCRB meeting and a series of actions, recommendations and resolutions have been adopted.

JCRB Resolution 30/1 concerning the shortening the existing deadlines for the inter-RMO review of CMCs implied a revision of the guidance document CIPM MRA-D-04 and changes in the JCRB CMC review website. Changes to the JCRB CMC review website were launched in early August 2013.

A new section was proposed for CIPM MRA D-04 at the 31st JCRB meeting: Section 12. "Greying-out of published CMCs" that has been developed according to the Action 30/1 of the 30th JCRB meeting.

A draft EURAMET paper "Towards a sustainable CIPM MRA" was discussed at the 31st JCRB meeting and resulted in an action for the other RMOs to contribute to the development of this paper. This will form an input document for the review of the CIPM MRA.

A new document (two part document) had been prepared as a revised version of the old "Request for Designation Information" form, and was presented during the 31st JCRB meeting. The first part contains the information on the expectations and obligations of being a Designated Institute (DI), the second part is the "Nomination of Designated Institute" form, which ensures that sufficient information is submitted when a nomination occurs. The form includes important new notes to ensure there is no ambiguity regarding the scope of the designation. The JCRB supported the new approach. The aim of the change is to ensure that institutes understand their obligations and responsibilities related to the CIPM MRA before they become DIs.

4. INTERGOVERNMENTAL AND INTERNATIONAL ACTIVITIES AND PROMOTION OF THE METRE CONVENTION

4.1. New States Parties to the Metre Convention (Member States) and new Associates of the CGPM (Associates) in 2013

At the end of 2013, there were 56 States Parties to the Metre Convention and 38 Associates of the CGPM.

The Republic of Colombia acceded to the Metre Convention on 6 February 2013 and the Republic of Iraq acceded on 20 August 2013. In addition, Mongolia became Associate of the CGPM on 7 August 2013.

4.2. Institutional collaboration with external organizations

The International Liaison and Communication Department of the BIPM has the role of promoting metrology to the scientific community, industry and the public. It undertakes this role through liaison activities with other intergovernmental organizations and international bodies and by participation in international forums. The BIPM has an ongoing relationship and significant interaction with more than thirty international organizations and provides or shares information with these bodies relating to the SI and the international comparability of measurements. Collaborations are both institutional and technical and in 2013, a typical year, BIPM staff travelled on around 120 separate occasions, amounting to more than one person year of time, to provide their expertise to such organizations and to the NMIs.

Key liaison activities are with intergovernmental organizations such as the World Health Organization (WHO), the IAEA, the WMO, the International Organization of Legal Metrology (OIML) and international bodies such as the International Organization for Standardization (ISO) and the International Laboratory Accreditation Cooperation (ILAC). Interaction varies from high-level discussions to participation in dedicated working groups but the objective remains the same: to promote the importance of measurement, the SI and the comparability of measurement and to ensure the appropriate use of metrology and the international infrastructure.

Considerable work was undertaken during 2013 on the overall BIPM strategy to underpin the development of future BIPM work programmes. This work is based on a major strategy exercise which has been carried out by the CCs and coordinated by the BIPM. Part of this exercise required the CCs to identify key stakeholders, an exercise which will help to ensure that the BIPM uses its liaison resources as effectively as possible. In addition to the organizations named above, BIPM staff liaised with the Codex Alimentarius Commission, the International Astronomical Union (IAU), the International Commission on Radiation Units and Measurements (ICRU), the International Commission on

Illumination (CIE), the International Earth Rotation and Reference Systems Service (IERS), the International Union of Pure and Applied Chemistry (IUPAC) and the World Anti-Doping Agency (WADA).

Notable achievements in 2013 were:

- The BIPM participated in two of the three meetings of the World Trade Organization (WTO) Committee on Technical Barriers to Trade held in 2013. This followed a decision by the WTO in late 2012 to grant *ad hoc* observer status to the BIPM. The participation opportunities are used to draw attention to the existence, importance and value to trade of the metrology infrastructure world-wide and to update the trade facilitation community on relevant developments.
- The BIPM contributed to the ILAC WG during the revision of the ILAC policy document dealing with Uncertainty in Calibration, which has now been published (ILAC-P14:01/2013 Uncertainty in Calibration).
- The CIPM decided that as part of its intention to encourage a stronger strategic perspective, it will identify one or two cross-cutting "grand metrology challenges" considering potential liaisons with the ILAC, the ISO and the OIML and other relevant international organizations with missions complementary to the BIPM. The CIPM will charge the Presidents of the CCs to assess the implications of these "grand metrology challenges" to their strategies and future programmes ready for a workshop in early 2015.
- A number of high-profile joint workshops were organized with international organizations including the IAEA and the ITU. See section 5.2 for further details.
- In April 2013 Dr David Burns of the Ionizing Radiation Department became a member representing the BIPM on the Scientific Committee of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (SSDLs), otherwise known as the SSDL Scientific Committee (SSC). The SSC is a standing advisory group established in 1986 to provide technical advice to the Directors General of the IAEA/WHO on the programme of work of the SSDL Network and to review and advise on the Dosimetry Programme of the IAEA. The SSC meets every two years at the IAEA headquarters in Vienna, Austria. The next meeting is planned for March 2014.
- The BIPM contributes to discussions about the needs and support for developing countries' technical infrastructure by participating in meetings of the Network on Metrology, Accreditation and Standardization for Developing Countries (DCMAS Network). In 2013 its particular focus was to secure ongoing United Nations Industrial Development Organization (UNIDO), and UNIDO managed, support for AFRIMETS.
- World Metrology Day is an annual event held on 20 May to commemorate the signing of the Metre Convention in 1875. The theme in 2013 was 'Measurements in daily life' a wide-ranging topic which concerns individuals in a multitude of situations and which highlights the all-pervading nature of metrology. World Metrology Day 2013 was particularly successful, with 49 000 hits on the website on 20 May alone and 171 000 for the whole of the month: this was more than double the number of hits in 2012. World Metrology Day is jointly delivered by the BIPM and the OIML, involving a dedicated website http://www.worldmetrologyday.org with a poster, press release and message from the Directors of the BIPM and the International Bureau of Legal Metrology (BIML) as well as events organized by NMIs to raise awareness of metrology. Details of 33 such events were posted on the website. In 2013 the poster was prepared with support from TUBITAK/UME, the Turkish NMI, and was provided in English and French. Participants translated the poster into a further 14 languages. Some NMIs have produced internet videos to raise awareness of the event. These videos are becoming increasingly popular and are posted on the dedicated website at http://www.worldmetrologyday.org/links.html. In addition to World Metrology Day, the BIPM and

the BIML collaborate regularly on a number of institutional and technical matters throughout the year.

4.3. Joint Committees

4.3.1. Joint Committee for Guides in Metrology (JCGM)

The JCGM met at the BIPM on 4 December 2013 for its annual plenary meeting. Six of the eight member organizations, except the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) and the International Electrotechnical Commission (IEC), were represented. Reports of its Working Groups (WG1 on the GUM and WG2 on the VIM) were presented.

The main topic of the WG1 Report concerned revision of the Guide to the Expression of Uncertainty in Measurement (GUM), which is being given the highest priority. WG1 has published a paper about the motivation for the revision (*Metrologia*, 2012, **49**, 702). WG1, in agreement with the BIPM, will organize a workshop at the BIPM which will allow experts to openly discuss their different views. The Workshop is planned for the first semester of 2015 following circulation of the first Committee Draft.

The 2013 activities of WG2 centered primarily on two key topics:

- reacting to the JCGM's request for WG2 to develop its own vocabulary on nominal properties
- further development of prototype annotations for inclusion in a possible Annotated VIM3.

WG2 decided that developing a stand-alone vocabulary on nominal properties is not the best solution for the scientific and technological communities, and that a "consolidated" vocabulary (fourth edition of the VIM) that contains 'measurement', as well as concepts such as 'examination', 'identification', 'classification', and 'ordering', as related to nominal and ordinal properties would be preferable. WG2 has developed nine draft annotations for the VIM3 in order to test the feasibility of such a system.

WG2 concluded its activities in 2013 with the development of a modified Plan of Work that will be presented to the JCGM as a proposal for formal endorsement in the future. The proposal for the development of a fourth edition of the VIM (VIM4) contains an extended scope to encompass a limited number of concepts related to nominal properties. A non-contradictory, consensus set of Generic and Specific principles has been developed by the WG2 to provide guidance in elaborating VIM4, but the language of the Definitions, Notes and Examples in VIM4 will be more 'reader-friendly' than in VIM3, and basic tools such as concept diagrams will be kept in a separate document.

The Annotations to VIM3 will give informative explanations of particular Definitions, Notes or Examples of the VIM3. An annotation may also propose a simplified equivalent definition when the VIM3 Definition is complicated by the use of a preferred term rather than one of its secondary terms. A procedure has been put in place within WG2 to maintain Word master files of the annotations, as well as an HTML master product for the open website, entitled "The Annotated VIM3".

Following discussion, the JCGM took two decisions:

- the document on the Proposed Modified JCGM WG2 Plan of Work be refined to include the VIM4 time frame and what is intended by the "Annotations to the VIM3" be clarified by the end of 2013 (The JCGM will then ask the Member Organizations for their comments on this refined version by end February 2014)
- the Annotated VIM3 electronic master file (in HTML format) be hosted on the JCGM web pages by the BIPM, with a first release expected for June 2014.

The JCGM formally decided that it will be Chaired by the BIPM for the period 2014 to 2016[‡‡‡].

4.3.2. Joint Committee for Traceability in Laboratory Medicine (JCTLM)

The annual joint meeting of the JCTLM Working Groups was held at the BIPM on 3 December 2013. This was followed by a JCTLM Members' and Stakeholders' Meeting on 4 and 5 December that brought together 70 attendees from the *in vitro* diagnostic industry, as well as from the clinical chemistry and laboratory medicine community. The first session of the meeting was on the 'Impact of Reference Measurement Systems on Clinical Evidence', the second session on 'Commutability', and the last session on 'JCTLM current and future activities'. The 12th meeting of the JCTLM Executive Committee was held at the BIPM on 6 December 2013.

The revised text of the Declaration of Cooperation (DoC) between the CIPM, the IFCC and the ILAC, and its Appendices III and IV have been approved by the three sponsoring organizations, and posted on the BIPM JCTLM website. The amendments made to the text were in line with the current review processes used by the JCTLM, as well as the revision in the harmonized standards (ISO 15194 and ISO 15193 relating to Certified Reference Materials and Reference Procedures) of the European Directive on *In Vitro* Medical Devices. In addition, a statement on the obligations for JCTLM Member Organizations was included in the Appendix IV.

In March 2013, the WG1 Cycle 9 reference materials, and measurement methods, and WG2 Cycle 7 reference measurement laboratory services approved by the Executive Committee during its 11th annual meeting in December 2012 were published in the database.

As of December 2013 the JCTLM Database contained:

- 299 available certified reference materials covering 11 categories of analytes. Of these reference materials, 33 are in List II, which includes reference materials value-assigned using internationally agreed protocols, and three are in List III, which covers reference materials with nominal properties;
- 156 reference measurement methods or procedures that represent about 80 different analytes in eight categories of analytes;
- 92 reference measurement services, delivered by nine reference laboratories and two NMIs in five countries and which cover six categories of analytes.

The WG1 Cycle 10 call for nominations of higher order reference materials and reference measurement methods or procedures, and the WG2 Cycle 8 call for nominations of reference measurement laboratory services were announced on the JCTLM website in January 2013, and email notifications were sent to about 350 potential contributors to the JCTLM. As of July 2013, 58 nominations for materials, 12 nominations for methods, and 12 nominations for services had been received and sent to Review Teams for evaluation.

ISO TC 212 WG2 is currently revising two normative standards of particular importance to the JCTLM processes, notably ISO 17511 and ISO 15195, and the BIPM, as a liaison A organization to ISO TC 212, has been active in this activity.

[‡‡‡] The Chair of the JCGM is held by one of its Member Organizations for renewable terms of three years. The BIPM has always been chosen as the JCGM Chair, thereby ensuring continuity and that the BIPM Director will chair forthcoming JCGM meetings. It also ensures that the JCGM Secretariat and JCGM web page will continue to be maintained by the BIPM.

5. MEETINGS AND WORKSHOPS AT THE BIPM

5.1. Meeting of representatives of Member States and NMI Directors

23-24 October 2013

The 100 attendees received presentations on CIPM and BIPM governance matters including the revised process for election of CIPM members and the reviews of the BIPM Pension Fund and Terms and Conditions for BIPM staff.

Presentations on the BIPM strategy and the Consolidated Planning Process included the Mission, Role and Objectives and the long-term financial plan for the BIPM. The strategy for the BIPM Work Programme including the proposed key activities for 2016-2019 were presented and discussed. Plans for the 25th CGPM were given and the proposals for a review of the CIPM MRA were discussed.

Other talks included: Progress towards the redefinition of the kilogram and an update on streamlining the operation of the CCM; Progress towards the 'new SI' – an overview from CODATA; and International Cooperation in the European Joint Metrology Research Programmes EMRP and EMPIR.

The four main outcomes from this meeting were:

- there is a need to review the effectiveness and efficiency of the CIPM MRA
- the timing of the 2014 CIPM meetings and the meeting of NMI Directors and Government Representatives needs to be finalized
- the Draft Resolution 'On the election of the International Committee for Weights and Measures' needs to be reviewed
- the CIPM was requested to reflect on the composition and terms of reference of the 'pre-meeting' on the dotation of the BIPM that will be held during a preparatory day to the 25th meeting of the CGPM.

5.2. Workshops in 2013

Workshop on Best Practices in CMC Reviews (held at the BIPM)

18-19 March 2013

Each RMO and CC had prepared and circulated a paper in advance of the workshop detailing their views on improving efficiency of the inter-regional CMC review process. The papers were presented at the workshop and were supplemented by presentations from a number of CC representatives which collectively formed the input for the discussions. The outcomes of the workshop were presented to and reviewed by the JCRB. The workshop resulted in a series of resolutions, recommendations and actions to improve the CMC review process.

20 years of the CCQM: Progress made, impact provided, lessons learned and future challenges (held at the BIPM)

17 April 2013

The workshop highlighted the remarkable progress in chemical metrology that had occurred during Dr R. Kaarls leadership of the CCQM.

BIPM-IAEA Workshop on carbon dioxide and methane stable isotope gas standards (held at the VSL, the Netherlands)

4 June 2013

Following the signing of the BIPM-IAEA memorandum of understanding in 2012, the BIPM and IAEA organized the workshop, which was hosted by the VSL, the Netherlands, with the aim of understanding the current status of CO_2 and CH_4 isotope ratio standards and their importance for accurate concentration measurements of these important greenhouse gases. The conclusions of the workshop were presented at the 30th meeting of the CCQM-GAWG (November 2013), and technical proposals for a key comparison (CCQM-K120) on CO_2 in air standards, to be coordinated by the BIPM and the NIST, were accepted. Initial work to develop measurement methods at the BIPM and validation standards for the comparison has started.

ITU/BIPM Workshop: Future of the International Time Scale (held at the ITU headquarters, Geneva, Switzerland)

19-20 September 2013

The workshop was jointly organized by the BIPM and the International Telecommunication Union (ITU) to establish closer cooperation in matters related to the proposed redefinition of UTC without leap second insertions.

The workshop provided an opportunity to get all available information on currently used and discussed precise frequency and time standards, sources and their characteristics, time scales and dissemination systems and different views on the future of UTC. It was intended primarily for the managerial and technical staff of State radiocommunication authorities involved in preparation for the World Radiocommunication Conference 2015. The workshop included sixteen invited presentations covering the various aspects of the discussion on the proposed modification of UTC. Representatives from the ITU, the BIPM, the International Astronomical Union (IAU), the International Earth Rotation and Reference Systems Service (IERS), the International Union of Geodesy and Geophysics (IUGG) and the ISO presented the views of their organizations. There were also speakers from the four Global Navigation Satellite Systems and two NMIs.

6. BIPM TRAVEL, VISITORS, SECONDEES AND GUEST WORKERS

6.1. Travel

BIPM staff attended approximately 70 conferences and meetings in 2013. Attendance totalled approximately 290 working days and involved 29 members of the BIPM staff. For a full breakdown of staff travel in 2013, including travel by the Director, please see the website http://www.bipm.org/en/publications/directors_report/travel.html

In addition more than 256 working days involving 21 members of the BIPM staff were spent in technical visits to 18 States in 2013.

6.2. Secondees and guest workers

P. Nogaś (Polish Space Research Centre (SRC)) for a cooperation on the improvement of GNSS time transfer, 23 April – 1 May 2013.

C. Kuanbayev (KazInMetr RSE), on secondment as the JCRB Executive Secretary, 1 October 2012 to 30 November 2014.

S. Lee (KRISS), 6 March to 5 June 2013, to work in the Chemistry Department.

M. Li (NIM), since 2 May 2013, to work in the Chemistry Department.

6.3. Visitors

More than 75 visitors from 28 States spent a total of 132 days in technical visits at the BIPM in 2013. For further details about these visits please see the website http://www.bipm.org/en/publications/directors_report/visitors.html

More than 1 300 attendees took part in meetings at the BIPM in 2013.

7. PUBLICATIONS

7.1. *Metrologia*

The publishing partnership with IOPP continues to work well. An option to publish open-access papers in *Metrologia* was introduced in April 2013, and September 2013 saw the smooth transfer of *Metrologia* to the IOPP's new manuscript-handling system, ScholarOne Manuscripts. Authors and referees alike will benefit from the advantages of the new system.

The Impact Factor of *Metrologia* remains the highest amongst the related journals; in 2012 (the latest year for which results are available) it rose again to 1.902.

Of many interesting papers, one that received particular attention in 2013 was the report by de Podesta *et al.* of a low-uncertainty measurement of the Boltzmann constant[§§§]; this paper was selected for a special feature in, and indeed inspired the cover illustration of, the August 2013 edition of *Physics World*.

Submissions to the journal remain high, and *Metrologia*'s online Technical Supplement is also doing well, with an average of one or two new reports added per week.

7.2. Website

The BIPM website continues to be the BIPM's primary means of communication; it contains a wealth of information and attracts interest from a diverse audience.

Since 2013 the BIPM makes its formal annual report (the *Rapport annuel aux gouvernements*) openly available on its website. Also added in 2013 were the reports of all the meetings of the General Conference to date, and an electronic Compendium of rules and practices applicable to the BIPM.

[§§§] de Podesta M., *et al*., A low-uncertainty measurement of the Boltzmann constant, *Metrologia*, 2013, **50**, 354.

Behind the scenes, work is progressing towards a new version of the website to be launched in 2014. Preparatory work in 2013 concentrated on agreeing an improved content structure and establishing a new visual identity for the BIPM. The new graphic design was successfully trialled during the October meetings of representatives of Member States and NMI Directors and the CIPM, through PowerPoint presentations and the installation of new "corporate design" posters in the main entrance halls around the site. It is now under discussion by the CIPM.

BIPM publications are listed in Appendix 1.

8. DIRECTOR'S OFFICE AND GENERAL SERVICES

The BIPM's administrative and support services were restructured in 2013. The former Finance, Administration and General Services Department was reorganized into two new offices (the Finance, Budget and Procurement Office and the Legal, Administration and Human Resources Office). At the same time, the responsibilities of the Secretariat were expanded to include the housekeeping functions. All the administrative and support services are managed from within the Director's Office. A new General Services grouping was created which incorporates the BIPM Workshop and building maintenance together with responsibilities for safety, quality and the BIPM grounds.

8.1. Finance, Budget and Procurement Office

The Finance, Budget and Procurement Office put considerable effort into the preparation of the long-term financial plan during 2013. This work included collaboration with the CIPM Sub-Committee on Finance on, among other things, the development of four scenarios that take into account potential increases of between 0 % and 2.5 % in the dotation from 2016 to 2023 and the predicted impact of each on the BIPM and its work. The long-term financial plan, including the scenarios, was presented to the meeting of NMI Directors and Government Representatives in October 2013. Development of the long-term financial plan will continue before it is presented to the 25th meeting of the CGPM (2014). The Finance, Budget and Procurement Office also collaborated with the CIPM Standing Sub-Committee on the BIPM Provident and Pension Fund and Health Insurance. Based on the input from the meeting of NMI Directors and Government Representatives, a couple of additional scenarios to increase the financial situation of the Pension and Provident Fund were identified. Full details of this collaborative work can be found in the report of the 102nd meeting of the CIPM.

Details of the 2012 Financial statements can be found in the "*Rapport annuel aux Gouvernements des Hautes parties contractantes sur la situation administrative et financière du Bureau International des Poids et Mesures*".

8.2. Legal, Administration and Human Resources Office

The Legal, Administration and Human Resources Office oversees human resources, legal and other services and relations with the Host State's authorities, with Member States and Associates of the CGPM, and with other States, intergovernmental organizations and international bodies. The Office's work covers legal and administrative affairs and the negotiation and daily management of contracts and agreements entered into by the BIPM.

Legal activities of the Legal, Administration and Human Resources Office include:

- Assistance to the Director on legal, administrative and human resources questions related to the BIPM and its activities and preparation of the elements necessary to allow his decision-making, in particular: law applicable to staff members of the BIPM; General international law, including privileges and immunities and any question on the interpretation and application of the BIPM constitutive and fundamental provisions; Agreements and contracts to which the BIPM is a party; and Procurement contracts.
- Provision of legal opinions necessary to ensure the legal certainty of the BIPM on institutional, procedural, administrative and human resources matters.
- Drafting of *notes verbales* and institutional correspondence of the BIPM, in particular with States and other intergovernmental organizations, and liaison with the latter's legal advisors and administrative authorities on legal and administrative matters.
- Contribution to the development of rules applicable to the BIPM and to its staff members (amendments to the RRI).
- Provide support to the department directors and section heads on legal, administrative and human resources questions of the BIPM and its activities.
- Participation in the proofreading of statutory BIPM publications.

Administrative activities of the Legal, Administration and Human Resources Office include in particular: administrative relations and protocol with the public institutions, such as ministries and embassies; Management of the customs operations; and Support to staff members in their administrative formalities in connection with the BIPM.

Human Resources activities of the Legal, Administration and Human Resources Office include in particular: Implementation of the Regulations, Rules and Instructions applicable to the BIPM staff members (RRI); HR management of appointments, secondments and internships, of the organizational structure and job descriptions; leave entitlements, performance evaluation, advancement and promotion.

8.3. Staff[****]

8.3.1. Appointments

- Mr Carlos Maggi, previously Quality Systems Coordinator at the National Research Council (NRC, Canada), was appointed as Quality, Health and Safety Manager as of 18 February 2013.
- As from 1 April 2013, the appointment of Ms Nina De Sousa Dias was converted to an indefinite-term appointment on a full time basis within the International Liaison and Communication Department.
- Mr Thomas Lavergne was appointed as an Assistant within the Mass Department as of 2 May 2013 for a two-year period.
- Dr Richard Davis had his consultancy contract extended until 31 December 2013.

8.3.2. Promotions and change of grade

- Ms Céline Fellag Ariouet was appointed *ad interim* PA to the Director as of 1 January 2013. She was the successful candidate in the competition organized for the position and took up the appointment of PA to the Director on 1 March 2013.

[****] See Appendix 4 for a list of BIPM staff and an organigram.

- Dr David Burns, *physicien principal* in the Ionizing Radiation Department, was promoted *physicien chercheur principal* from 1 January 2013.
- Ms Laïla Dell'Oro, *secrétaire* in the Finance, Administration and General Services Department, was promoted *secrétaire principale* from 1 January 2013.

8.3.3. Changes of responsibility

The reorganization of administrative and support services mentioned at the start of this section resulted in the following changes in responsibilities:

- Ms Sigrid Arlen heads the Legal, Administration and Human Resources Office. She will manage Ms Laïla Dell'Oro.
- Ms Isabelle Andernack heads the Finance, Budget and Procurement Office. She will manage Ms Daniela Etter and Mr François Ausset.
- Ms Céline Fellag Ariouet heads the Secretariat and Housekeeping Office. She will continue to manage Ms Frédérique de Hargues and Ms Nina De Sousa Dias (for her work in the Secretariat). She will also manage Ms Isabel Neves, Ms Maria José Fernandes, Ms Angela Mendes de Matos and Ms Arminda da Ponte.
- Mr Carlos Maggi for safety, quality and the grounds. He will manage Mr Carlos Dias Nunes and Mr André Zongo. He will also manage Mr Enrique Dominguez and Mr César Neves as site guardians.

8.3.4. Research fellows

- Dr Sangil Lee, scientist at the Korea Research Institute of Standards and Science (KRISS, Republic of Korea), was on secondment in the Chemistry Department from 6 March to 5 June 2013.
- Dr Ming Li, scientist at the National Institute of Metrology (NIM, China), began a secondment in the Chemistry Department on 1 May 2013 to 30 April 2014 and from 1 November 2014 to 31 October 2015.
- The appointment of Dr Norbert Stoppacher, Research Fellow in the Chemistry Department, was extended until 31 December 2014.

8.3.5. Departures

- Ms Marie-Jeanne Martin, Secretary-Accountant within the Finance, Administration and General Services Department, retired on 28 June 2013.
- Ms Brigitte Perent, Financial and Administrative Director, left the BIPM on 1 December 2013.

8.4. Secretariat and Housekeeping Office

The Secretariat's activities are an essential part of the increasing coordination role of the BIPM. Following reorganization in September 2013, the Housekeeping activities of the former Finance, Administration and General Services Department were merged with the Secretariat to become a separate entity, the Secretariat and Housekeeping Office, within the Director's Office under the supervision of

Ms Céline Fellag Ariouet. The merger of the housekeeping functions into the Secretariat has allowed the organization and running of all meetings held at the BIPM and offsite to be brought together. The resulting synergy has led to an immediate improvement in efficiency and an estimated reduction in the cost of meetings of 20 thousand Euros for 2013.

The meetings managed by the Secretariat include those of the Consultative Committees and their Working Groups, as well as the meetings of the CIPM, CIPM bureau, Directors of NMIs and States Representatives, Joint Committees and special workshops. In 2013, more than 1 300 attendees took part in meetings at the BIPM. See Appendix 3 for a full list of meetings held at the BIPM in 2013.

Work started in 2013 on planning for the 25th meeting of the CGPM, which will be held off-site in November 2014 and which will be organized and managed by the Secretariat and Housekeeping Office.

Within the Office, the Secretariat provides secretarial and administrative support to all members of staff (e.g. support for travel, visa requests and registration for international symposia). Among its other responsibilities, the BIPM Secretariat and Housekeeping Office deals with the requests for use of the CIPM MRA logo and is responsible for the central database which supplies data to the BIPM intranet and website.

The Secretariat circulates the documents for communication with Member States, Associates of the CGPM and NMI Directors. In addition it publishes the Working documents on dedicated restricted areas of the BIPM website for the CIPM, NMI Directors and States Representatives and Consultative Committees and Working Groups. It also maintains records of calibration certificates, sends the certificates to NMIs and issues the internal monthly "News" of events.

8.5. Safety, Quality and Grounds

The BIPM Quality Management System was reviewed in the yearly Quality Management System Review meeting on 5 October 2012. A new integrated BIPM Quality Manual, which is in compliance with ISO/IEC 17025:2005 and the ISO Guide 34:2009 has been approved and implemented. The regular internal and external on-site peer reviews which took place during 2013 did not result in any major non-conformities. Minor non-compliances and recommendations for improvement have been addressed.

The BIPM Quality Management System will be presented at the EURAMET TC Q meeting to be held in Cavtat, Croatia, on 9 April 2014.

The BIPM has completed and launched an Occupational Health and Safety Management System based on the requirements of BS OHSAS 18001:2007. Revision 2 of the English and French versions of the BIPM's Occupational Health and Safety Manual were approved and published on 2 October 2013. Risk assessment, urgent action and incident/accident/near-miss procedures have been implemented. All staff members involved have been trained in the use of these procedures. The system is now fully operational.

Annexe 1 / Appendix 1

PUBLICATIONS

Publications du BIPM pour l'année 2013 / BIPM Publications 2013

- BIPM Core data 2012, 4 p. / 4 pp.
- *BIPM e-News* (juin et décembre 2013 / June and December 2013).
- Mission, Rôle et Objectifs du BIPM, 8 p. / BIPM: Mission, Role and Objectives, 8 pp.
- Comité consultatif de l'acoustique, des ultrasons et des vibrations, 8e session (2012), 29 p. / Consultative Committee for Acoustics, Ultrasound and Vibration, 8th meeting (2012), 29 pp.
- Comité consultatif d'électricité et magnétisme, 28e session (2013), 24 p. / Consultative Committee for Electricity and Magnetism, 28th meeting (2013), 24 pp.
- Comité consultatif des longueurs, 15e session (2012), 44 p. / Consultative Committee for Length, 15th meeting (2012), 44 pp.
- Comité consultatif pour la masse et les grandeurs apparentées, 14e session (2013), 39 p. / Consultative Committee for Mass and Related Quantities, 14th meeting (2013), 39 pp.
- Comité consultatif de photométrie et radiométrie, 21e session (2012), 34 p. / Consultative Committee for Photometry and Radiometry, 21st meeting (2012), 34 pp.
- Comité consultatif pour la quantité de matière : métrologie en chimie, 19e session (2013), 34 p. / Consultative Committee for Amount of Substance: Metrology in Chemistry, 19th meeting (2013), 34 pp.
- Comité consultatif des rayonnements ionisants, 23e session (2012), 16 p. / Consultative Committee for Ionizing Radiation, 23rd meeting (2012), 16 pp.
- Comité consultatif de thermométrie, 26e session (2012), 34 p. / Consultative Committee for Thermometry, 26th meeting (2012), 34 pp.
- Comptes rendus de la 24e réunion de la Conférence générale des poids et mesures (2011), 684 p. / Proceedings of the 24th meeting of the General Conference on Weights and Measures (2011), 684 pp.
- Notification des parts contributives dues par les Gouvernements des Hautes Parties contractantes pour l'entretien du Bureau international des poids et mesures et des souscriptions des États et Entités Économiques associés à la Conférence générale en 2013, 4 p. / 4 pp.
- Procès-verbaux du Comité international des poids et mesures, 101e session (2012), 80, 210 p. / International Committee for Weights and Measures, 101st meeting (2012), 80, 210 pp.
- Rapport annuel aux Gouvernements des Hautes Parties contractantes sur la situation administrative et financière du Bureau international des poids et mesures en 2012, 162 p. / 162 pp.
- Rapport annuel du BIPM sur les activités du temps (2012), 121 p. / BIPM Annual Report on Time Activities (2012), 121 pp.

- Rapport du directeur sur l'activité et la gestion du Bureau international des poids et mesures (2012), **13**, 124 p. / Director's Report on the Activity and Management of the BIPM (2012), **13**, 124 pp.
- Rapports BIPM :
  - 2013/01 (17 pages)
  - 2013/02 (24 pages)

Publications scientifiques du BIPM pour l'année 2013 / BIPM scientific publications 2013

Masses / Mass

Publications extérieures / External publications

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- Solve S., Chayramy R., Stock M., A bias source for the voltage reference of the BIPM watt balance, *IEEE Trans. Instrum. Meas.*, 2013, 62, 1594-1599.
- Stock M., Watt balance experiments for the determination of the Planck constant and the redefinition of the kilogram, *Metrologia*, 2013, 50, R1-R16.
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- Barat P. *et al*., Report detailing requirements of NMIs for storage and transfer equipment compatible with existing apparatus, *NPL REPORT ENG 43*, ISSN 1754-2987, January 2013.
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Temps / Time

Publications extérieures / External publications

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- Solve S., Chayramy R., Picard A., Kiss A., Fang H., Robertsson L, De Mirandés E., Stock M., A bias source for the voltage reference of the BIPM watt balance. *IEEE Trans. Instrum. Meas.*, 2013, 1594-1599.
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- Rapport annuel du BIPM sur les activités du temps (2012), 2013, **7**, 121 p. (rapport disponible uniquement sur la page internet www.bipm.org/en/publications/time_activities.html) / *BIPM Annual Report on Time Activities for 2012*, **7**, 121 pp., available only at www.bipm.org/en/publications/time_activities.html.
- *Circulaire T* (mensuelle), 8 p. / *Circular T* (monthly), 8 pp.
- *UTC rapide (UTCr)* (hebdomadaire), 1 p. / *Rapid UTC* (*UTCr*) (weekly), 1 pp.
- Panfilo G., Harmegnies A., Tisserand L., A new weighting procedure for UTC. Report to the CCTF Working Group on TAI and to the CCTF working group on Time Scale Algorithms, December 2013.

Électricité / Electricity

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- Chayramy R., Solve S., A very low thermal EMF computer-controlled scanner, *Meas. Sci. Technol.*, 2013, 24, 035008.
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- Usuda T., Bruns T., Wright J., Filtz J.-R., Esward T., Arrhén F., Fletcher N., Report on the BIPM Workshop on Challenges in Metrology for Dynamic Measurement, *Rapport BIPM*-2013/01, 17 p. / 17 pp.

Rayonnements ionisants / Ionizing Radiation

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- Allisy-Roberts P.J., Kessler C., Burns D.T., Summary of the BIPM.RI(I)-K5 comparison for air kerma in ^{137}Cs gamma radiation, *Metrologia*, 2013, 50, *Tech. Suppl*., 06001.
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- Kessler C., Allisy-Roberts P.J., Minniti R., Comparison of the standards for air kerma of the NIST and the BIPM for ^{60}Co gamma radiation, *Metrologia*, 2013, 50, *Tech. Suppl*., 06002.
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- Kessler C., Saito N., Kurosawa T., Key comparison BIPM.RI(I)-K1 of the air kerma standards of the NMIJ, Japan and the BIPM in ^{60}Co gamma radiation, *Metrologia*, 2013, 50, *Tech. Suppl*., 06006.
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Chimie / Chemistry

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- Josephs R.D., Stoppacher N., Li M., Routes to Macromolecular/Biomolecular Purity (CON 3) - Concept Paper on SI Value Assignment of Purity: Model for the classification of peptides for primary structure purity determinations, Input for BAWG Drafting Group.

Annexe 2 / Appendix 2

CERTIFICATS ET NOTES D'ÉTUDE / CERTIFICATES AND STUDY NOTES

Entre le 1er janvier 2013 et le 31 décembre 2013, 77 certificats et 4 notes d'étude ont été délivrés. / In the period from 1 January 2013 to 31 December 2013, 77 Certificates and 4 Study Notes were issued.

1.1 Certificats /Certificates

2013

1.	1 Ω resistance standard, Leeds and Northrup type 4210, No. 1 915 096 *	NIMT, Thaïlande/ Thailand
2.	1 Ω resistance standard, Leeds and Northrup type 4210B, No. 285282	Id.
3.	100 Ω resistance standard, Tinsley type 5685A, No. 15241/15	Id.
4.	100 Ω resistance standard, Alpha Electronics type CSR102, No. 02217	Id.
5.	100 Ω resistance standard, TEGAM type SR102, No. A2010106SR102 *	Id.
6.	10 000 Ω resistance standard, Leeds and Northrup type 4214B, No. 1 917 542 *	Id.
7.	10 000 Ω resistance standard, TEGAM type SR104, No. K201090330104	Id.
8.	1 Ω resistance standard, Leeds and Northrup type 4210, No. 1681958*	NIS, Égypte/Egypt
9.	1 Ω resistance standard, Leeds and Northrup type 4210, No. 1684330*	Id.
10.	1 Ω resistance standard, Leeds and Northrup type 4210, No. 1679692*	Id.
11.	10 000 Ω resistance standard, ESI type SR 104, No. 307109	Id.
12.	Ionization chamber NE 2571, No. 2719 in a ^{60}Co gamma-ray beam*	NMISA, Afrique du Sud/South Africa
13.	Ionization chamber NE 2571, No. 2719 in x-rays beams*	Id.
14.	Ionization chamber PTW 30012, No. 0064 in a ^{60}Co gamma-ray beam*	Id.
15.	Ionization chamber PTW 30012, No. 0064 in x-rays beams*	Id.
16.	Ionization chamber NE 2530, No. 649 in a ^{137}Cs gamma-ray beam*	Id.
17.	Ionization chamber PTW W32002, No. 055 in gamma-ray beams	Id.
18.	Ionization chamber NE 2611, No. 2611 in a ^{60}Co gamma-ray beam*	CRRD, Argentine/ Argentina
19.	Ionization chamber NE 2611, No. 133 in medium-energy x-rays*	Id.
20.	10 000 Ω resistance standard, Leeds and Northrup type 4214B, No. 1 784 815*	BEV, Autriche/Austria
21.	1 Ω resistance standard, Leeds and Northrup type 4210, No. 1 611 312*	Id.
22.	1 Ω resistance standard, Leeds and Northrup type 4210B, No. 1 915 322*	Id.

* Standards marked with an asterisk have been calibrated previously at the BIPM.

23.	1 Ω resistance standard, NMIA, NML type, No. 64191*	Id.
24.	10 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01660	Id.
25.	100 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01661*	Id.
26.	100 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01469*	Id.
27.	1 Ω resistance standard, Leeds and Northrup type 4210, No. 1 870 794*	SMD, Belgique/ Belgium
28.	1 Ω resistance standard, Leeds and Northrup type 4210, No. 1 816 196*	Id.
29.	1 Ω resistance standard, CSIRO type, No. 64174*	Id.
30.	100 Ω resistance standard, TEGAM type SR102, No. A2010199SR102*	Id.
31.	10 000 Ω resistance standard, ESI type SR104, No. 718011*	Id.
32.	10 000 Ω resistance standard, ESI type SR104, No. G 207078730104*	NMC, Singapour/ Singapore
33.	1 Ω resistance standard, CSIRO type, No. 64206*	Id.
34.	1 Ω resistance standard, Tinsley type 5685A, No. 246570*	MSL, Nouvelle-Zélande/ New Zealand
35.	100 Ω resistance standard, Tinsley type 5685A, No. 248814*	Id.
36.	10 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01575	INM, Roumanie/Romania
37.	10 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01576	Id.
38.	100 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01577	Id.
39.	100 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01578	Id.
40.	10 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01277*	SMD, Belgique/ Belgium
41.	100 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01075*	Id.
42.	10 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01181*	CMI, République tchèque/ Czech Republic
43.	100 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01323*	Id.
44.	100 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01326*	Id.
45.	1 kg mass standard, 1K3*	NML-SIRIM, Malaisie/Malaysia
46.	1 kg mass standard, 1Kc*	Id.
47.	1 kg mass prototype, No. 4*	États-Unis d'Amérique/ United States of America
48.	1 kg mass prototype, No. 3*	Espagne/Spain

49.	100 pF capacitance standard, Andeen-Hargerling model AH11A, No. 01110 *	NML-SIRIM, Malaisie/Malaysia
50.	10 pF capacitance standard, Andeen-Hargerling model AH11A, No. 01111*	Id.
51.	10 pF capacitance standard, Andeen-Hargerling model AH11A, No. 01112*	Id.
52.	Ionization chamber NE 2571, No. 2676 in a ^{60}Co gamma-ray beam*	GUM, Pologne/Poland
53.	Ionization chamber Radcal RC6M, No. 9065 in low-energy x-rays*	NRPA, Norvège/Norway
54.	Ionization chamber Radcal RC6M, No. 9065 in mammography x-rays	Id.
55.	Ionization chamber Capintec PR-06G, No. 8429 in medium-energy x-rays*	Id.
56.	Ionization chamber Capintec PR-06G, No. 8429 in a ^{60}Co gamma-ray beam*	Id.
57.	Ionization chamber NE 2561, No. 099 in medium-energy x-rays	Id.
58.	Ionization chamber NE 2561, No. 099 in a ^{60}Co gamma-ray beam*	Id.
59.	Ionization chamber Exradin A6, No. XQ102232 in gamma-ray beam	Id.
60.	Zener diode voltage standard, No. 9170714*	DMDM, Serbie/Serbia
61.	Ionization chamber PTW 23344, No. 0844 in low-energy x-rays *	IAEA
62.	Ionization chamber PTW 23344, No. 0957 in low-energy x-rays	Id.
63.	Ionization chamber NE 2611, No. 145 in medium-energy x-rays *	Id.
64.	Ionization chamber NE 2561, No. 265 in medium-energy x-rays *	Id.
65.	Ionization chamber FC65G, No. 1551 in a ^{60}Co gamma-ray beam	Id.
66.	Ionization chamber TEC/NPL 2611B, No. 242 in a ^{60}Co gamma-ray beam*	Id.
67.	Ionization chamber NE 2611A, No. 211 in a ^{60}Co gamma-ray beam*	Id.
68.	1 kg mass prototype, No. 2*	Roumanie/Romania
69.	1 kg mass standard in stainless steel, No. 81*	INM, Roumanie/Romania
70.	1 kg mass prototype, No. 70*	Allemagne/ Germany
71.	1 kg mass standard "A" in platinum-iridium*	NPL, Royaume-Uni/ United Kingdom
72.	1 kg mass standard in stainless steel, 1K4*	NML-SIRIM, Malaisie/Malaysia
73.	1 kg mass standard in stainless steel, 1Kr*	Id.
74.	Ionization chamber NE 2561, No. 168 in medium-energy x-rays*	LNMRI, Brésil/Brazil
75.	Ionization chamber NE 2561, No. 168 in a ^{60}Co gamma-ray beam*	Id.
76.	Ionization chamber NE 2561, No. 264 in medium-energy x-rays*	Id.

77.	Ionization chamber NE 2561, No. 264 in a ^{60}Co gamma-ray beam*	Id.

1.2 Notes d'étude / Study Notes

2013

1.	1 Ω resistance standard, Yokogawa type 2781, No. 64VT4001	NIMT, Thaïlande/ Thailand
2.	10 000 Ω resistance standard, TEGAM type SR104, No. K2011000430104	Id.
3.	Ionization chamber NE 2611, No. 213 in a ^{60}Co gamma-ray beam	CRRD, Argentine/ Argentina
4.	1 pF capacitance standard, Andeen-Hagerling model AH11A, No. 01113	NML-SIRIM, Malaisie/Malaysia

Annexe 3 / Appendix 3

RÉUNIONS ET PRÉSENTATIONS AU SIÈGE DU BIPM / MEETINGS AND PRESENTATIONS AT THE BIPM

Réunions organisées par le BIPM / Meetings organized by the BIPM

Les réunions suivantes se sont tenues au siège du BIPM entre le 1er janvier 2013 et le 31 décembre 2013 / The following meetings were held at the BIPM in 2013:

- 14e réunion du CCM et réunions de ses groupes de travail, du 18 au 22 février 2013 / The 14th meeting of the CCM and meetings of the CCM Working Groups – 18 to 22 February 2013.
- Réunion du bureau du CIPM, les 4 et 5 mars 2013, les 17 et 18 juin 2013, et les 20 et 21 octobre 2013 / Bureau of the CIPM meeting – 4 to 5 March 2013, 17 to 18 June 2013 and 20 to 21 October 2013.
- Réunion bilatérale BIPM-ILAC, le 6 mars 2013 / BIPM and ILAC bilateral meeting – 6 March 2013.
- Réunion quadripartite BIPM-ILAC-ISO-OIML, le 7 mars 2013 / BIPM, ILAC, ISO and OIML four-partite meeting – 7 March 2013.
- Réunion bilatérale BIPM-OIML, le 7 mars 2013 / BIPM and OIML bilateral meeting – 7 March 2013.
- 28e réunion du CCEM et réunions de ses groupes de travail, du 11 au 15 mars 2013 / The 28th meeting of the CCEM and meetings of the CCEM Working Groups – 11 to 15 March 2013.
- 30e réunion du JCRB, le 20 mars 2013 / The 30th meeting of the JCRB – 20 March 2013.
- 21e réunion de la Section I du CCRI, du 25 au 28 mars 2013 / The 21st meeting of the CCRI(I) – 25 to 28 March 2013.
- Comité "Science et métrologie" de l'Académie des Sciences – le 8 avril 2013 / 8 April 2013.
- 19e réunion du CCQM et réunions de ses groupes de travail, du 12 au 19 avril 2013 / The 19th meeting of the CCQM and meetings of the CCQM Working Groups – 12 to 19 April 2013.
- Réunion du Groupe de travail du CCPR sur les comparaisons clés, du 22 au 23 avril 2013 / The CCPR Working Group on Key Comparisons (WG-KC) – 22 to 23 April 2013.
- 20e réunion de la Section III du CCRI, du 24 au 26 avril 2013 / The 20th meeting of the CCRI(III) – 24 to 26 April 2013.
- 22e réunion de la Section II du CCRI, du 13 au 16 mai 2013 / The 22nd meeting of the CCRI(II) – 13 to 16 May 2013.
- 24e réunion du CCRI, le 17 mai 2013 / The 24th meeting of the CCRI – 17 May 2013.
- CODATA – le 10 juin 2013 / 10 June 2013.
- 21e réunion du CCU, les 11 et 12 juin 2013 / The 21st meeting of the CCU – 11 to 12 June 2013.
- Première partie de la 102e session du CIPM, du 19 au 21 juin 2013 / Session I of the 102nd meeting of the CIPM – 19 to 21 June 2013.
- Seconde partie de la 102e session du CIPM, les 21, 22 et 25 octobre 2013 / Session II of the 102nd meeting of the CIPM – 21 to 22 and 25 October 2013.

- Réunion des représentants des États Membres et des directeurs des laboratoires nationaux de métrologie, les 23 et 24 octobre 2013 / Meeting of Representatives of Member States and NMI Directors – 23 to 24 October 2013.
- 9e réunion du CCAUV, du 28 au 31 octobre 2013 / The 9th meeting of the CCAUV – 28 to 31 October 2013.
- Réunion du Groupe de travail 2 du JCGM sur le VIM, du 2 au 5 décembre 2013 / JCGM-WG2 (VIM) meeting – 2 to 5 December 2013.
- Réunion des groupes d'examen du JCTLM, le 3 décembre 2013 / JCTLM Review Teams meeting – 3 December 2013.
- Réunion des membres et parties prenantes du JCTLM, les 4 et 5 décembre 2013 / JCTLM Members-Stakeholders meeting – 4 to 5 December 2013.
- Réunion du Comité exécutif du JCTLM, les 6 et 7 décembre 2013 / JCTLM Executive Committee – 6 to 7 December 2013.
- Réunion du Groupe de travail 1 du JCGM sur le GUM, du 9 au 12 décembre 2013 / JCGM-WG1 (GUM) meeting – 9 to 12 December 2013.

Présentations au siège du BIPM / Presentations at the BIPM

- M. Van Camp (Observatoire Royal de Belgique), L'eau, l'élément indomptable de la gravimétrie ? – le 23 mai 2013 / 23 May 2013.
- F. Ramirez Rossi (CNRS), The pygmies: another application of weights and measures – le 6 juin 2013 / 6 June 2013.
- M. du Sautoy (BBC documentary), Precision: The measure of all things – time and distance – les 6, 13 et 20 septembre 2013 / 6, 13 and 20 September 2013.
- S. Solve (BIPM), Toward a new BIPM Key Comparison in Electricity… – le 26 septembre 2013 / 26 September 2013.

Annexe 4 / Appendix 4

LISTE DU PERSONNEL DU BUREAU INTERNATIONAL DES POIDS ET MESURES / STAFF OF THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES

au 31 décembre 2013 / on 31 December 2013

Directeur / Director: M. Milton

Masses / Mass: A. Picard (M. Stock, directeur par interim / *interim* director)
P. Barat, H. Fang, C. Goyon-Taillade, F. Idrees[1], A. Kiss, T. Lavergne, E. de Mirandés

Temps / Time: E.F. Arias
A. Harmegnies, Z. Jiang, H. Konaté, W. Lewandowski, G. Panfilo, G. Petit, L. Robertsson, L. Tisserand

Électricité / Electricity: M. Stock
R. Chayramy, N.E. Fletcher, R. Goebel, A. Jaouen[2], B. Rolland, S. Solve[3]

Rayonnements ionisants / Ionizing radiation: J.M. Los Arcos
D.T. Burns, S. Courte, C. Kessler, C. Michotte, M. Nonis, S. Picard, G. Ratel, P. Roger

Chimie / Chemistry: R.I. Wielgosz
T. Choteau, A. Daireaux, E. Flores Jardines, R.D. Josephs, P. Moussay, N. Stoppacher, J. Viallon, S.W. Westwood

Bureau du directeur / Director's Office

Juridique, administration et ressources humaines / Legal, Administration and Human Resources: S. Arlen
L. Dell'Oro

Finances, budget et achats / Finance, Budget and Procurement: I. Andernack
F. Ausset, D. Etter

Secrétariat et entretien des locaux / Secretariat and housekeeping: C. Fellag Ariouet
A. Da Ponte, M.-J. Fernandes, F. de Hargues, A. Mendes de Matos, I. Neves

Relations internationales et communication / International Liaison and Communication:
A.S. Henson
S. Maniguet[4], C. Thomas, N. De Sousa Dias[5], J.R. Miles, C. Planche, R. Sitton

Services informatiques / IT Services: R.I. Wielgosz
L. Le Mée, T. Nguyen

[1] Également à la chimie / Also Chemistry
[2] Sous le régime de l'invalidité / Under the invalidity scheme
[3] En détachement au NIST depuis le 1er juillet 2012 / On secondment to the NIST since 1 July 2012
[4] Également à la chimie / Also Chemistry
[5] Également au secrétariat / Also Secretariat

Services généraux / General services

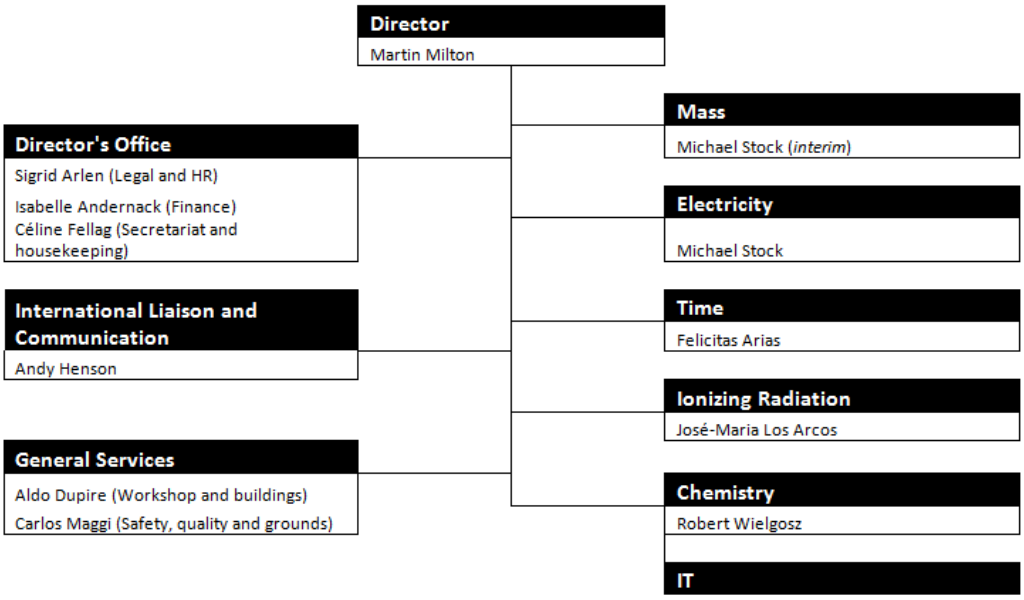
Sécurité, qualité et extérieurs / Safety, Quality and Grounds: C. Maggi
C. Dias Nunes, A. Zongo

Atelier de mécanique et entretien du site / Workshop and Buildings: A. Dupire
P. Benoit, F. Boyer, M. de Carvalho[6], E. Dominguez[7], P. Lemartrier, C. Neves[7], S. Segura, B. Vincent

Directeurs honoraires / Emeritus directors: T.J. Quinn, A.J. Wallard

Physicien chercheur principal honoraire / Honorary Principal Research Physicist:
R.S. Davis

Organigramme du siège du BIPM / Organigram of the BIPM headquarters



[6] Sous le régime de l'invalidité / Under the invalidity scheme
[7] Également aux services généraux / Also General Services

Annexe 5 / Appendix 5

LISTE DES SIGLES UTILISÉS DANS LE PRÉSENT VOLUME / ACRONYMS USED IN THE PRESENT VOLUME

AFRIMETS	Système intra-africain de métrologie/Inter-Africa Metrology System
AIEA	Agence internationale de l'énergie atomique
AMA	Agence mondiale antidopage
APMP	Asia/Pacific Metrology Programme
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency (Australie/Australia)
BEV	*Bundesamt für Eich- und Vermessungswesen* (Autriche/Austria)
BIML	Bureau international de métrologie légale/International Bureau of Legal Metrology
BIPM	Bureau international des poids et mesures/International Bureau of Weights and Measures
CC	Consultative Committee of the CIPM
CCAUV	Comité consultatif de l'acoustique, des ultrasons et des vibrations/Consultative Committee for Acoustics, Ultrasound and Vibration
CCC	Cryogenic current comparator/comparateur cryogénique de courant
CCEM	Comité consultatif d'électricité et magnétisme/Consultative Committee for Electricity and Magnetism
CCL	Comité consultatif des longueurs/Consultative Committee for Length
CCM	Comité consultatif pour la masse et les grandeurs apparentées/Consultative Committee for Mass and Related Quantities
CCPR	Comité consultatif de photométrie et radiométrie/Consultative Committee for Photometry and Radiometry
CCQM	Comité consultatif pour la quantité de matière : métrologie en chimie/Consultative Committee for Amount of Substance: Metrology in Chemistry
CCRI	Comité consultatif des rayonnements ionisants/Consultative Committee for Ionizing Radiation
CCRI(I)	CCRI Section I: x- and gamma rays, charged particles
CCRI(II)	CCRI Section II: Measurement of radionuclides
CCRI(III)	CCRI Section III : Neutron measurements
CCT	Comité consultatif de thermométrie/Consultative Committee for Thermometry
CCTF	Comité consultatif du temps et des fréquences/Consultative Committee for Time and Frequency
CCU	Comité consultatif des unités/Consultative Committee for Units
CEI	Commission électrotechnique internationale
CGPM	Conférence générale des poids et mesures/General Conference on Weights and Measures
CIE	Commission internationale de l'éclairage/International Commission on Illumination
CIPM	Comité international des poids et mesures/International Committee for Weights and Measures

CIPM MRA	CIPM Mutual Recognition Arrangement/Arrangement de reconnaissance mutuelle du CIPM
CMC	Calibration and Measurement Capability/Aptitude en matière de mesures et d'étalonnages
CMI-IIR	Czech Metrological Institute, Inspectorate for Ionizing Radiation/*Český Metrologický Institut, Inspektorát Pro Ionizující Záření* (République tchèque/Czech Republic)
CNRS	Centre national de la recherche scientifique (France)
CODATA	Committee on Data for Science and Technology
COOMET	Coopération métrologique entre les États d'Europe centrale/Euro-Asian Cooperation of National Metrology Institutions
CRRD	Regional Reference Centre for Dosimetry (Argentine/Argentina)
DCMAS	Network on Metrology, Accreditation and Standardization for Developing Countries/Réseau de métrologie, d'accréditation et de normalisation pour les pays en développement
DMDM	Directorate of Measures and Precious Metals (Serbie/Serbia)
EMRP	European Metrology Research Programmed/Programme européen de recherche en métrologie
EMPIR	European Metrology Programme for Innovation and Research/Programme européen d'innovation et de recherche en métrologie
ENEA	*Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile* (Italie/Italy)
ERMS	Ensemble of Reference Mass Standards/Ensemble d'étalons de masse de référence du BIPM
EURAMET	European Association of National Metrology Institutes
FTIR	Fourier transform infrared spectroscopie/Spectroscopie
GAWG	CCQM Working Group on Gas Analysis
GLONASS	*Globalnaya Navigatsionnaya Sputnikovaya Sistem*/Global Navigation Satellite System (Fédération de Russie/Russian Federation)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUM	Guide pour l'expression de l'incertitude de mesure/Guide to the Expression of Uncertainty in Measurement
HCHO	Formaldéhyde/Formaldehyde
HTML	HyperText Markup Language
IAEA	International Atomic Energy Agency
IAU	International Astronomical Union
ICRM	International Committee for Radionuclide Metrology
ICRM 2013	19th International Conference on Radionuclide Metrology and its Applications
ICRU	International Commission on Radiation Units and Measurements
IEC	International Electrotechnical Commission
IERS	International Earth Rotation and Reference Systems Service/Service international de la rotation terrestre et des systèmes de référence

IFCC	International Federation of Clinical Chemistry and Laboratory Medicine/Fédération internationale de chimie clinique et médecine de laboratoire
IFIN-HH	"*Horia Halubei*" National Institute of Research and Development for Physics and Nuclear Engineering (Roumanie/Romania)
ILAC	International Laboratory Accreditation Cooperation
INM	Instituto Nacional de Metrología de Colombia (Colombie/Colombia)
IPK	International prototype of the kilogram
IRA	Institut universitaire de radiophysique appliquée (Suisse/Switzerland)
IRMM	Institute for Reference Materials and Measurements, European Commission/Institut des matériaux et mesures de référence, Commission européenne
ISO	Organisation internationale de normalisation/International Organization for Standardization
ITU	International Telecommunication Union
IUGG	International Union of Geodesy and Geophysics
IUPAC	International Union of Pure and Applied Chemistry
JCGM	Joint Committee for Guides in Metrology/Comité commun pour les guides en métrologie
JCRB	Joint Committee of the Regional Metrology Organizations and the BIPM/Comité mixte des organisations régionales de métrologie et du BIPM
JCTLM	Joint Committee for Traceability in Laboratory Medicine/Comité commun pour la traçabilité en médecine de laboratoire
KazInMetr RSE	Kazakh Institute of Metrology RSE (Kazakhstan)
KCDB	BIPM key comparison database/Base de données du BIPM sur les comparaisons clés
KCRV	key comparison reference value
KRISS	Korea Research Institute of Standards and Science (République de Corée/Republic of Korea)
LCM	Laboratoire commun de métrologie (France)
LNE-CNAM	LNE Conservatoire national des arts et métiers (France)
LNE-LNHB	LNE Laboratoire national Henri Becquerel (France)
LNE-SYRTE	LNE Systèmes de Références Temps-Espace (France)
LNMRI	*Laboratório Nacional de Metrologia das Radiações Ionizantes* (Brésil/Brazil)
MASM	Mongolian Agency for Standardization and Metrology (Mongolie/Mongolia)
MSL	Measurement Standards Laboratory (Nouvelle-Zélande/New Zealand)
NIM	National Institute of Metrology (Chine/China)
NIMT	National Institute of Metrology (Thaïlande/Thailand)
NIS	National Institute for Standards (Égypte/Egypt)
NIST	National Institute of Standards and Technology (États-Unis d'Amérique/USA)
NMC, A*STAR	National Metrology Centre, Agency for Science, Technology and Research (Singapour/Singapore)
NMI	National Metrology Institute
NMISA	National Metrology Institute of South Africa (Afrique du Sud/South Africa)
NML-SIRIM	National Metrology Laboratory, SIRIM Berhad (Malaisie/Malaysia)

NPL	National Physical Laboratory (Royaume-Uni de Grande-Bretagne et d'Irlande du Nord/UK)
NRPA	National Radiation Protection Authority (Norvège/Norway)
OAWG	CCQM Working Group on Organic Analysis
OIML	Organisation internationale de métrologie légale/International Organization of Legal Metrology
OMC	Organisation mondiale du commerce
OMM	Organisation météorologique mondiale
OMS	Organisation mondiale de la santé
ONUDI	Organisation des Nations Unies pour le développement industriel
PJVS	Programmable Josephson voltage standard
POLATOM RC	National Centre for Nuclear Research, Radioisotope Centre (Pologne/Poland)
PPP	Precise Point Positioning/Logiciel de positionnement précis
PTB	*Physikalisch-Technische Bundesanstalt* (Allemagne/Germany)
QHE	quantum Hall effect
QNMR	quantitative nuclear magnetic resonance
RMO	Regional Metrology Organization
SI	Système international d'unités/International System of Units
SIM	*Sistema Interamericano de Metrología/* Système interaméricain de métrologie/Inter-American Metrology System
SIR	Système international de référence pour les mesures d'activité d'émetteurs de rayonnement gamma/ International Reference System for gamma-ray emitting radionuclides
SIRTI	Instrument de transfert du SIR/Transfer Instrument of the SIR
SMD	Service Métrologie Scientifique (Belgique/Belgium)
SNS	Superconductor-normal metal-superconductor/supraconducteur-normalsupraconducteur
SSC	SSDL Scientific Committee
SSDL	Secondary Standards Dosimetry Laboratories of the IAEA
TAI	Temps atomique international/ International Atomic Time
TDCR	Triple-to-Double Coincidence Ratio Technique/Rapport des coïncidences triples aux coïncidences doubles
TPR	Tissue Phantom Ratio/Rapport tissue-fantôme
TWSTFT	Two-Way Satellite Time and Frequency Transfer/Comparaison de temps et de fréquence par aller et retour sur satellite
UAI	Union astronomique internationale
UEC	Universal efficiency curves
UGGI	Union géodésique et géophysique internationale
UIT	Union internationale des télécommunications
UNIDO	United Nations Industrial Development Organization
UTC	Temps universel coordonné/Coordinated Universal Time
UTCr	UTC rapide/rapid UTC

VIM	Vocabulaire international de métrologie – Concepts fondamentaux et généraux et termes associés (3e édition)/International Vocabulary of Metrology, Basic and General Concepts and Associated Terms (3rd edition)
VNIIM	D.I. Mendeleyev Institute for Metrology, Rostekhregulirovaniye of Russia (Fédération de Russie/Russian Federation)
VSL	Van Swinden Laboratorium (formerly NMi-VSL) (Pays-Bas/Netherlands)
WADA	World Anti-Doping Agency
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
XRCD	X-ray crystal density