Revised SI and Testing in Africa – the BIPM perspective

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BIPM

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Bureau International des Poids et Mesures

The objectives of the BIPM

Approved by Resolution 3 of the 26th CGPM

To **represent** the worldwide measurement community aiming to maximise its uptake and impact

To be a **centre for scientific and technical** collaboration between Member States providing capabilities for international measurement comparisons on a shared-cost basis.

To be the **coordinator** of the worldwide measurement system ensuring it gives comparable and internationally-accepted measurement results

Fulfilling our mission and objectives is underpinned by our work in:

- ***capacity** Highlight aims to achieve a global balance between the metrology capabilities in Member States.*
- ***knowledge transfer,** which ensures that our work has the greatest impact.*

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– the intergovernmental organization through which Member States act together on matters related to measurement science and measurement standards.

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About the BIPM

20 May 2019 - World Metrology Day

The new definitions of the SI base units have now come into effect!

Metrology area:

- Acoustics, Ultrasound and Vibration
- Chemistry and Biology
- Electricity and Magnetism
- Ionizing Radiation
- Length
- Mass and related quantities
- Photometry and Radiometry
- Thermometry
- Time and Frequency
- Units

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The International System of Units (SI)

Introduction | Definition of the SI | SI base units | SI prefixes | The 2018 revision of the SI | How to realize the SI units | SI Brochure | History

→ The recommended practical system of units of measurement is the International System of Units (*Système International d'Unités*), with the international abbreviation **SI**.

The SI is defined by the **SI Brochure**, which is published by the BIPM.

In a landmark decision, the BIPM's Member States voted on 16 November 2018 to revise the SI, changing the world's definition of the kilogram, the ampere, the kelvin and the mole.

This decision, made at the 26th meeting of the General Conference on Weights and Measures (CGPM), means that from 20 May 2019 all SI units are defined in terms of constants that describe the natural world. This will assure the future stability of the SI and open the opportunity for the use of new technologies, including quantum technologies, to implement the definitions.

The seven defining constants of the SI are:

- the caesium hyperfine frequency $\Delta\nu_{Cs}$;
- the speed of light in vacuum c;
- the Planck constant h;
- the elementary charge e;
- the Boltzmann constant k;
- the Avogadro constant N_A; and
- the luminous efficacy of a defined visible radiation K_{cd}.

The SI was previously defined in terms of seven base units and derived units defined as products of powers of the base units. The seven base units were chosen for historical reasons, and were, by convention, regarded as dimensionally independent: the metre, the kilogram, the second, the ampere, the kelvin, the mole, and the candela. This role for the base units continues in the present SI even though the SI itself is now defined in terms of the defining constants above.

Metrology area: AUV EM L M PR QM RI T TF U

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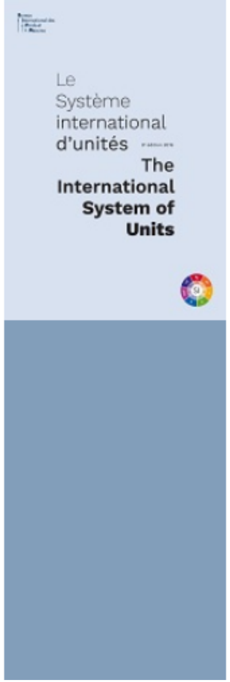
SI Brochure: The International System of Units (SI)

9th edition (2019) | Appendix 1 | Appendix 2 | Appendix 3 | Appendix 4 | Previous editions

→ We are pleased to present the 9th edition of the SI Brochure (2019), which defines and presents the *Système International d'Unités*, the SI (known in English as the International System of Units).

- **Complete brochure** (French and English)
- Concise summary
- Text in English
- Text in French

- Appendix 1: Decisions of the CGPM and the CIPM
- Appendix 2: Practical realization of the definition of some important units
- Appendix 3: Units for photochemical and photobiological quantities
- Appendix 4: Historical notes on the developpment of the SI and its base units



Some small changes that come into effect for laboratories working at the highest levels in the mass and electricity communities.

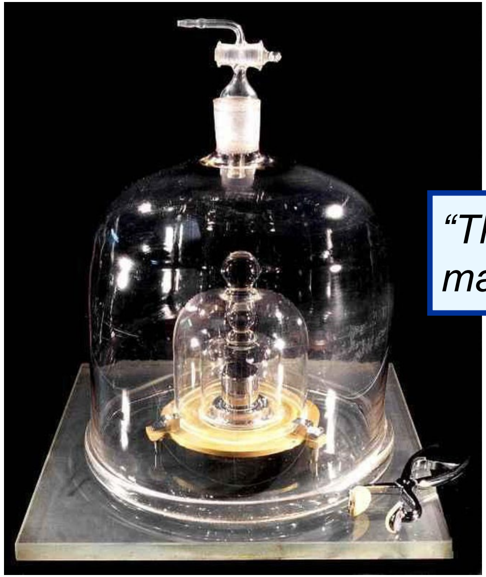
for electricity:
https://www.bipm.org/utils/common/pdf/CC/CCEM/ccem_guidelines_revisedSI.pdf

for mass:
https://www.bipm.org/utils/common/pdf/CC/CCM/BIPM_Note-on-kilogram-redefinition.pdf

Voltage : + 0.1 ppm
Resistance : + 0.02 ppm

17 lab with smallest uncertainties affected

In May 2019 the definition of the kilogram changed

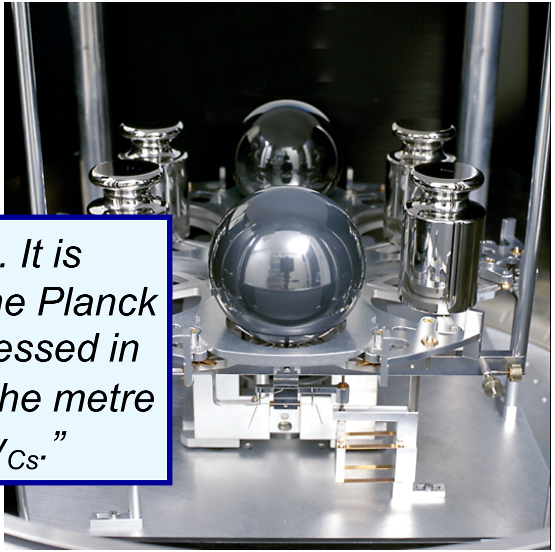


FROM

"The kilogram is the unit of mass; it is equal to the mass of the International Prototype of the Kilogram"

TO

"The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant h to be 6.62607015 $\times 10^{-34}$ when expressed in the unit J·s, which is equal to $kg \cdot m^2 \cdot s^{-1}$, where the metre and the second are defined in terms of c and $\Delta\nu_{Cs}$."



Impact for NMIs

Adjustments

- Care has been taken to ensure that the value of the kilogram remains constant across all the phases of the implementation of the new definition so no adjustments to national mass scales will be necessary

Uncertainties and CMCs

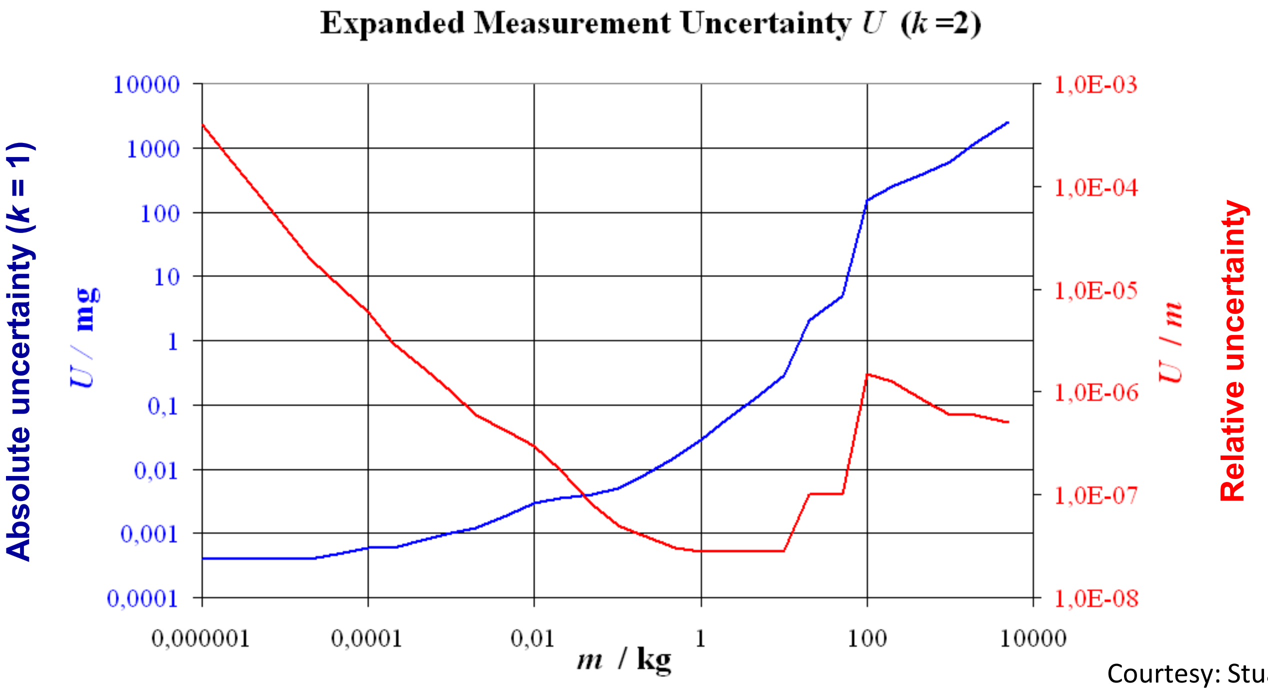
- CMCs will need to be reviewed to take into account the additional (10 µg) uncertainty in the IPK after redefinition (20 May 2019)
- BIPM will be issuing guidance on how the uncertainties on their previous calibrations will change
- As a guide only uncertainties of about 50 µg or lower (at 1 kg) will need to be increased as a result of the redefinition

Traceability

- NMIs can continue to take traceability from the BIPM.
- BIPM traceability will initially be through the IPK (with the additional uncertainty) and then, after the completion of the first KC of realisation experiments, to the Consensus Value

Dissemination

- To achieve traceability for different mass values we need to subdivide and multiply the scale from 1 kilogram
- This increases the relative uncertainty as we move away from 1 kilogram



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Courtesy: Stuart Davidson, NPL

Evolution of traceability for the SI unit of mass

Phase	Time scale	Description	Source of traceability	Uncertainty of BIPM mass calibrations	Role of realization experiments	Dissemination of mass from NMIs with realization experiments
0	Until 20 May 19[1]	Traceability to the IPK	$m_{\mathrm{IPK}} \equiv 1$ kg $u_{m_{\mathrm{IPK}}} \equiv 0$	$u_{\mathrm{stab}}(t)$	Measurement of *h*	Dissemination from national prototype traceable to IPK
1	20 May 19 - date 1[2]	Traceability to the Planck constant via the IPK, with additional uncertainty from the (new) definition	$m_{\mathrm{IPK}} = 1$ kg $u_{m_{\mathrm{IPK}}} = 10\ \mu g$	$\approx \sqrt{u_{m_{\mathrm{IPK}}}^2 + u_{\mathrm{stab}}^2(t)}$	Contribute to Key Comparison (KC), improve and resolve discrepancies	Dissemination from national prototype traceable to IPK, with 10 µg added uncertainty
2	date 1 – date 2[3]	Traceability to the Planck constant, dissemination from a consensus value[4] (CV)	Consensus value (CV)	$\approx \sqrt{u_{\mathrm{CV}}^2 + u_{\mathrm{stab}}^2(t)}$	contribute to CV (via KC), improve experiments and resolve discrepancies	Dissemination from consensus value with uncertainty $\approx \sqrt{u_{\mathrm{CV}}^2 + u_{\mathrm{stab.NMI}}^2(t)}$
3	from date 2	Traceability to the Planck constant, dissemination by individual realizations	Fixed value of *h* $u(h) \equiv 0$	(Uncertainty of BIPM realization experiment)	Realization of the unit of mass, Participation in KCs to demonstrate equivalence	Dissemination from validated realization experiments with the uncertainty of the experiment. The terms of the CIPM MRA are applicable.

Date 1: 20 May 19 Date 2: CV following first KCRV (early 2020) Date 3: Agreement and stability of realisation experiments (2030-2040?)

Transition to the use of individual realisation experiments (Phase 3)

a) A minimum of five consistent realization experiments which:

   I. Achieve Key Comparison results with a relative standard uncertainty of 40 parts in 10^9 or better

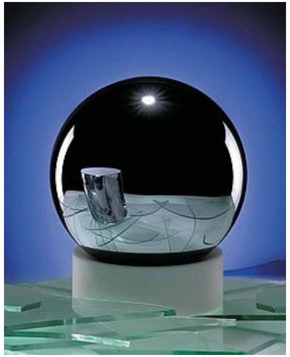
   II. Demonstrate consistency with the KCRV

   III. Demonstrate stability by producing consistent (equivalent) results for two consecutive Key Comparisons

b) At least two of the realization experiments meeting the above criteria should have uncertainties less than 20 parts in 10^9.

c) The consistent set of experiments must include two independent methods of realizing the SI unit of mass (e.g. Kibble balance and X-ray crystal density experiments)

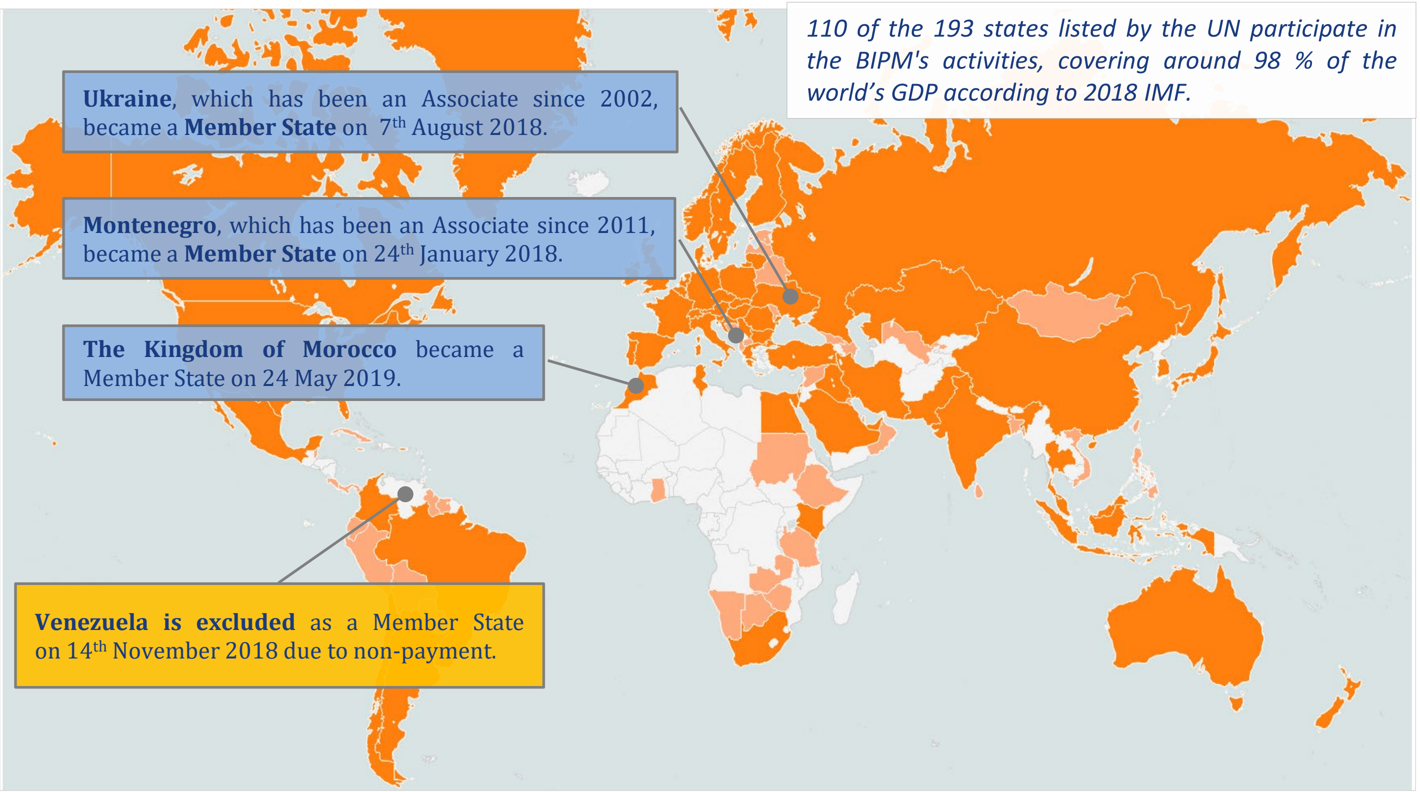
d) The difference between the Consensus Value for the kilogram (determined from three last 3 Key Comparison results) and the KCRV for the final Key Comparison is less than 5 parts in 10^9.



Member States and Associates

As of 24 May 2019, there are:

- 60 Member States*
- 42 Associates of the CGPM (States and Economies)



** The official term is "State Parties to the Metre Convention"; the term "Member States" is its synonym and used for easy reference.*

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Joint BIPM, OIML, ILAC and ISO declaration


Bureau International des Poids et Mesures
INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES

OIML
INTERNATIONAL ORGANISATION OF LEGAL METROLOGY

ilac
INTERNATIONAL LABORATORY ACCREDITATION COOPERATION

ISO
INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

JOINT

BIPM, OIML, ILAC, and ISO

DECLARATION ON

METROLOGICAL TRACEABILITY

This document was originally signed
9th November 2011, then

updated and reaffirmed
13th November 2018

Martin Milton
Director of the BIPM

Stephen Patoray
BIML Director

Merih Malmqvist Nilsson
ILAC Chair

Sergio Mujica
ISO Secretary General

Joint declaration on metrological traceability

The Joint Declaration was **refreshed and resigned in November 2018,** having been first reviewed by the four parties and agreed at the Quadripartite meeting of March 2018. The revised text was circulated and agreed by the CIPM

https://www.bipm.org/utils/common/pdf/BIPM-OIML-ILAC-ISO_joint_declaration_2018.pdf

Changes to the joint BIPM, OIML, ILAC and ISO declaration

The refresh of the Joint BIPM, OIML, ILAC and ISO declaration was suggested by ISO WG44 during the revision of ISO/IEC 17025, who wanted to reference the Joint Declaration in the revised standard. The Quadripartite meeting agreed that there would be no substantive changes but the document should be reordered.

The following changes were made:

- The order was reversed such that the description of the four signatory bodies came after, rather than before, the recommendations
- The descriptions of the organizations were generalized in as much as data that changes frequently would not be explicitly quoted (e. g the exact number of members of the originations)
- The OIML-CS system was introduced and the now redundant OIML Basic Certificate System and OIML MAA deleted.
- Some small parts of the text were “polished”.

Thank you.

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