

Information for users on the proposed redefinition of the SI

The International System of Units¹, the SI, which is based on the **second**, the **metre**, the **kilogram**, the **ampere**, the **kelvin**, the **mole** and the **candela** (the base units), is being revised to update the definitions of four of these units. In November 2018 revised definitions of the **kilogram**, **ampere**, **kelvin** and **mole** are expected to be approved by the General Conference on Weights and Measures (CGPM), the international body responsible for the global comparability of measurements. They are expected to come into force on 20 May 2019.

The revised definitions will be based on seven physical constants (e.g. the speed of light, the Planck constant and the Avogadro constant) and are therefore inherently stable. The quantities have been chosen so that the revised definitions will not need to be modified to accommodate future improvements in the technologies used to realize them. The revision of the SI in this way was foreseen in Resolutions of the CGPM adopted in 2011 and 2014^{2,3}. Additional requirements contained in these Resolutions will ensure a smooth transition to the four revised definitions. Most users will not notice the change. A new edition of the SI Brochure¹ will provide essential information for users and will be available after the revised definitions are adopted formally. Guidance on the practical realization of the units will be available⁴⁻⁸.

Some information about how these changes might affect the different areas of measurement is given below:

- **The kilogram** will be defined in terms of the Planck constant, guaranteeing long-term stability of the SI mass scale. The kilogram can then be realized by any suitable method, (e.g. the Kibble (watt) balance or the Avogadro (X-ray crystal density) method). Users will be able to obtain traceability to the SI from the same sources used at present (the BIPM, national metrology institutes and accredited laboratories). International comparisons will ensure their consistency. The value of the Planck constant will be chosen to ensure that there will be no change in the SI kilogram at the time of redefinition. The uncertainties offered by NMIs to their calibration customers will also be broadly unaffected.
- **The ampere** and other electrical units, as practically realized at the highest metrological level, will become fully consistent with the definitions of these units. The transition from the 1990 convention to the revised SI will result in small changes of all disseminated electrical units. For the vast majority of measurement users, no action need be taken as the volt will change by about 0.1 parts per million and the ohm will change by even less. Practitioners working at the highest level of accuracy may need to adjust the values of their standards and review their measurement uncertainty budgets.
- **The kelvin** will be redefined with no immediate effect on temperature measurement practice or on the traceability of temperature measurements, and for most users, it will pass un-noticed. The redefinition lays the foundation for future improvements. A definition free of material and technological constraints enables the development of new and more accurate techniques for making temperature measurements traceable to the SI, especially at extremes of temperature. After the redefinition, the guidance on the practical realization of the kelvin will support its world-wide dissemination by describing primary methods for measurement of thermodynamic temperature and equally through the defined scales ITS-90 and PLTS-2000.
- **The mole** will be redefined with respect to a specified number of entities (typically atoms or molecules) and will no longer depend on the unit of mass, the kilogram. Traceability to the mole

can still be established via all previously employed approaches including, but not limited to, the use of mass measurements along with tables of atomic weights and the molar mass constant M_u . Atomic weights will be unaffected by this change in definition and M_u will still be 1 g/mol, although now with a measurement uncertainty. This uncertainty will be so small that the revised definition of the mole will not require any change to common practice.

The revised definitions of the kilogram, ampere, kelvin and mole will have no impact on the second, the metre and the candela.

- **The second** will continue to be defined in terms of the hyperfine transition frequency of the caesium 133 atom. The traceability chain to the second will not be affected. Time and frequency metrology will not be impacted.
- **The metre** in the revised SI will continue to be defined in terms of the speed of light, one of the fundamental constants of physics. Dimensional metrology practice will not need to be modified in any way and will benefit from the improved long-term stability of the system.
- **The candela** will continue to be defined in terms of K_{cd} , a technical constant for photometry and will therefore continue to be linked to the watt. Traceability to the candela will still be established with the same measurement uncertainty via radiometric methods using absolutely-calibrated detector.

The SI has been revised several times since its formal adoption by the CGPM in 1960. However, redefining four base units at one time is unprecedented, requiring simultaneous world-wide collaborations in diverse fields of metrology. As in the past, care has been taken to ensure that there will be no perceptible impact on daily life and that measurements made with previous definitions of the units remain valid within their measurement uncertainties. Few users outside national metrology laboratories will notice the changes. Reaching the experimental accuracies and fulfilling the conditions requested in the CGPM resolutions has been a remarkable accomplishment which will ensure that the SI continues to meet the needs of even the most demanding users.

1. <http://www.bipm.org/en/publications/si-brochure/>
2. <http://www.bipm.org/en/CGPM/db/24/1/>
3. <http://www.bipm.org/en/CGPM/db/25/1/>
4. <http://www.bipm.org/en/publications/mises-en-pratique/>
5. http://www.bipm.org/cc/CCM/Allowed/15/02A_MeP_kg_141022_v-9.0_clean.pdf
6. <http://www.bipm.org/cc/CCEM/Allowed/26/CCEM-09-05.pdf1>
7. http://www.bipm.org/cc/CCT/.../MeP-K-14_DRAFT_Dec_2015.pdf
8. http://www.bipm.org/cc/CCQM/Allowed/22/CCQM16-04_Mole_m_en_p_draft.pdf