Bureau International des Poids et Mesures

Information for users about the redefinition of the SI

Updated May 20, 2019

The International System of Units, the SI, which is based on the **second**, the **metre**, the **kilogram**, the **ampere**, the **kelvin**, the **mole** and the **candela** (the base units), has been revised to update the definitions of four of these units. In November 2018 revised definitions of the **kilogram**, **ampere**, **kelvin** and **mole** were approved by the General Conference on Weights and Measures (CGPM), the international body responsible for the global comparability of measurements, with the adoption of Resolution 1 (2018)[1]. The revised definitions came into force on 20 May 2019.

The revised definitions are based on seven physical constants (for example 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. Additional requirements contained in these Resolutions have ensured a smooth transition to the four revised definitions. Most users will not notice the change. A new edition of the SI Brochure[2] provides essential information for users, including, in its Appendix 2, guidance on the practical realization of the units[3].

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

- ***The kilogram*** is now defined in terms of the Planck constant, guaranteeing long-term stability of the SI mass scale. The kilogram can be realized by any suitable method, (for example the Kibble (watt) balance or the Avogadro (X-ray crystal density) method). Users are able to obtain traceability to the SI from the same sources used as before (the BIPM, national metrology institutes and accredited laboratories). International comparisons will ensure their consistency. The value of the Planck constant was chosen to ensure that there was 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, have become fully consistent with the definitions of these units. The transition from the 1990 convention to the revised SI has resulted in small changes to all disseminated electrical units. For the vast majority of measurement users, no action need be taken as the volt changed by about 0.1 parts per million and the ohm changed by even less. Practitioners working at the highest level of accuracy will have adjusted the values of their standards and reviewed their measurement uncertainty budgets.

- ***The kelvin*** has been redefined with no immediate effect on temperature measurement practice or on the traceability of temperature measurements, and for most users, it will pass unnoticed. 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. The

guidance on the practical realization[3] of the kelvin supports 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*** has been redefined with respect to a specified number of entities (typically atoms or molecules) and no longer depends 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 are unaffected by this change in definition and M_u is still 1 g/mol, although now with a measurement uncertainty. This uncertainty is so small that the revised definition of the mole does not require any change to common practice.

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

- ***The second*** continues to be defined in terms of the hyperfine transition frequency of the caesium 133 atom. The traceability chain to the second is not affected. Time and frequency metrology are not impacted.

- ***The metre*** continues to be defined in terms of the speed of light, one of the fundamental constants of physics. Dimensional metrology practice does not need to be modified in any way and will benefit from the improved long-term stability of the system.

- ***The candela*** continues to be defined in terms of $K_{cd,}$ a technical constant for photometry and therefore continues to be linked to the watt. Traceability to the candela is established with the same measurement uncertainty via radiometric methods using absolutely-calibrated detectors.

The SI has been revised several times since its formal adoption by the CGPM in 1960. However, redefining four base units at one time was 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. www.bipm.org/en/CGPM/db/26/1/
2. www.bipm.org/en/publications/si-brochure/
3. www.bipm.org/en/publications/mises-en-pratique/

This is an updated version of a note prepared in 2017 by the Consultative Committees of the CIPM in preparation for the revision of the SI. This updated version takes into account the adoption of Resolution 1 by the CGPM in 2018, and the implementation of the revised SI on 20 May 2019.