VSL

National Metrology Institute

The 7 SI Base Units

Mass — kilogram (kg)

The kilogram is defined by taking the fixed numerical value of the **Planck constant** *h* to be **6.626 070 15** × 10^{-34} when expressed in the unit J s, which is equal to kg m^2 s^{-1}, where the metre and the second are defined in terms of the speed of light in vacuum, and the transition frequency of the caesium 133 atom. The new definition of the kilogram is realized by balancing the gravitational force on a weight, to an electromagnetic force, using an instrument known as a 'Kibble balance'. VSL mass calibrations are traceable to the definition of the kilogram by yearly comparison with 1 kg artefacts at the 'Bureau International des Poids et Mesures'.

Length — Meter (m)

The metre is defined by taking the fixed numerical value of the **speed of light in vacuum *c*** to be **299 792 458** when expressed in the unit m s^{-1},where the second is defined in terms of the caesium frequency $\Delta\nu_{Cs}$.

The speed of light is a universal constant of nature, making it ideal as a length standard. At VSL, traceability to the metre is most commonly achieved using the wavelength of the 633 nm radiation from an iodine-stabilised helium-neon laser, with an uncertainty of about 2 parts in 10^{11}. This is equivalent to measuring the Earth's mean circumference to about 1 mm.

Time — Second (s)

The second is the duration of **9 192 631 770** oscillations of the radiation corresponding to the transition between two energy levels of the caesium 133 atom. VSL acquired its first caesium clocks around 1970. Since then, VSL's atomic clocks help the Netherlands run on time by disseminating the national time scale and by contributing to Coordinated Universal Time (UTC).

Electricity — Ampere (A)

The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the **elementary charge *e*** to be **1.602 176 634 × 10^{-19}** when expressed in the unit C, which is equal to A s, where the second is defined in terms of the caesium frequency $\Delta\nu_{Cs}$.
At VSL, the ampere is realized by using Ohm's law and using practical realizations of the derived units the volt and the ohm, based on the Josephson and quantum Hall effects, respectively, or by using the relation I = C·dU/dt and practical realizations of the SI derived units the volt and the farad F and of the SI base unit second.

Temperature — Kelvin (K)

The kelvin is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the **Boltzmann constant *k*** to be **1.380 649 × 10^{-23}** when expressed in the unit J K^{-1}, which is equal to kg m^2 s^{-2} K^{-1}, where the kilogram, metre and second are defined in terms of *h*, *c* and $\Delta\nu_{Cs}$.
At VSL, we realise the ITS-90, which is a practical temperature scale and approximates thermodynamic temperature.

Amount of substance — Mole (mol)

The mole, symbol mol, is the SI unit of amount of substance. One mole contains exactly **6.022 140 76 × 10^{23}** elementary entities. This number is the fixed numerical value of the **Avogadro constant, N_A**, when expressed in the unit mol^{-1} and is called the Avogadro number.
The amount of substance, symbol *n*, of a system is a measure of the number of specified elementary entities. An elementary entity may be an atom, a molecule, an ion, an electron, any other particle or specified group of particles.

Luminous intensity — Candela (cd)

The candela, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the **luminous efficacy of monochromatic radiation of frequency 540 × 10^{12} Hz, K_{cd}**, to be **683** when expressed in the unit lm W^{-1}, which is equal to cd sr W^{-1}, or cd sr kg^{-1} m^{-2} s^3, where the kilogram, metre and second are defined in terms of *h*, *c* and $\Delta\nu_{Cs}$.

At VSL, the candela is realised using an electrical-substitution radiometer.

The role of VSL

VSL manages and develops primary measurement standards and primary reference materials on behalf of the Dutch government. These measurement standards are directly traceable to the Basic SI standards and are the foundation for reliable measurements in science, industry, fair trade and other areas. Services as calibration and proficiency testing make that society and industry never have to doubt on their measurement results.

For more information about VSL visit our website - **www.vsl.nl**