NPL
National Physical Laboratory

Units of measurement

The International System (SI) base units are realised at the National Physical Laboratory (NPL). These units are then used throughout the United Kingdom for trade, industry, science and health & safety.

Formally agreed in 1960, the SI is at the centre of all modern science and technology. The definition and realisation of the base and derived units is an active research topic for metrologists with more precise methods being introduced as they become available.

Time — Unit: second — Symbol: (s)

The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.

NPL built the world's first accurate caesium atomic clock in 1955 and paved the way for a new better definition of the second based on the caesium 133 atom. NPL's atomic clocks help the UK run on time through dissemination of the national time scale and by contributing to Co-ordinated Universal Time.

Length — Unit: metre — Symbol: (m)

The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.

The speed of light is a universal constant of nature making it ideal as a length standard.

At NPL the metre is most commonly realised through the wavelength of the 633 nm radiation from an iodine-stabilised helium-neon laser, with an uncertainty of about 3 parts in 10^{11}. This is equivalent to measuring the Earth's mean circumference to about 1 mm.

Mass — Unit: kilogram — Symbol: (kg)

The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

Note: K, the international prototype of the kilogram is made of platinum (90%) and iridium (10%) and is kept at the International Bureau of Weights and Measures (BIPM) in France; the British copy (No. 18) is kept at NPL.

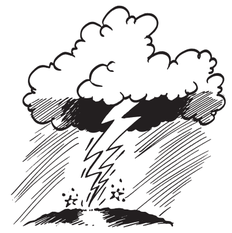
The kilogram is the last remaining base unit to be defined as a physical object. All standards of mass must ultimately be traceable to this one object. The search is on in a number of scientific laboratories (including NPL) to try to find a way of defining the kilogram in terms of a fundamental constant, two key approaches are being pursued; building an electrical kilogram and counting atoms.

Electricity — Unit: ampere — Symbol: (A)

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2 x 10^{-7} newton per metre of length.

The ampere is difficult to realise in practice with sufficient accuracy, so it is defined via the watt.

The electrical power generated in a controlled experiment is compared to mechanical power, and using an accurate measurement of resistance the ampere can be calculated (as Power = (Current)^2 x Resistance).



Substance — Unit: mole — Symbol: (mol)

The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.

Note: The carbon 12 atoms are unbound, at rest and in their ground state.

Most chemical measurements require the determination of the composition of mixtures, rather than the absolute determination of the amount of substance present (e.g. the concentration of lead in drinking water). So, in general, chemists measure ratios of amounts of substance rather than amount of substance directly.

Light — Unit: candela — Symbol: (cd)

The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

At NPL the candela is realised using the cryogenic absolute radiometer, an instrument capable of measuring optical power (in watts) in a laser beam to an uncertainty of better than 0.01%. The measured laser beam is used to calibrate a photometer, a detector with a filter to mimic the spectral response of the human eye, which is then used to measure the luminous intensity (in candelas) emitted by a tungsten lamp (or other types of light source) with an uncertainty of 0.2%.

Temperature — Unit: kelvin — Symbol: (K)

The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

The triple point of water is the unique temperature at which the three phases of water (solid, liquid and vapour) co-exist. It is fractionally higher than the melting point of water, being 0.01 °C or 273.16 K.

Visit our website for lots of measurement-related information: **www.npl.co.uk**