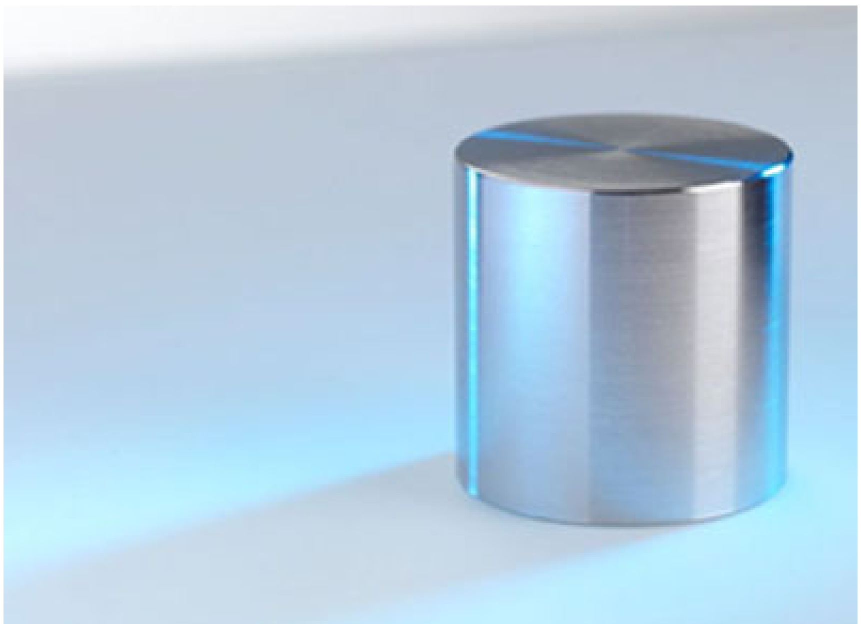
Kilogram celebrates its 125th birthday

September 25 2014, by Stuart Davidson



The UK national standard kilogram removed from its protective casing

The IPK has been the global standard for mass for the last 125 years; it was sanctioned at the first General Conference on Weights and Measures (CGPM) on 7-9 September 1889 in Paris. This is likely to be the last landmark birthday of the IPK as current experiments to redefine the kilogram are due for completion as early as 2018. These will relate mass to naturally occurring constants rather than a physical object such as the IPK.

The IPK is made from an alloy of platinum (90%) and iridium (10%).

This mixture was chosen because platinum has a high density so the IPK could be made with a small volume and surface area; the addition of iridium improves the hardness. The IPK has a fixed mass approximately equivalent to one litre of water at 4 °C, but its weight varies depending on local gravity.

When the IPK was manufactured, 40 copies were also made from the same platinum-iridium alloy. These were distributed for use as national standards so scientists would not have to go back to the IPK (held in Sèvres, just outside Paris) every time they needed an accurate measurement of mass. These national standards are checked for deviations against the IPK every 40 years. At the last check, in 1989, the maximum deviation was about 50 micrograms. These changes are not fully accounted for and the corresponding lack of stability of the mass scale poses a problem for scientists. NPL scientist Dr Stuart Davidson comments that: "While the current definition of the kilogram is fit for purpose, we know that it can't be perfectly stable because all artefacts will change their mass with time. It is a concern that we know that the IPK must be changing, but there is currently no way to actually measure this change."

Two experiments are under way to redefine the kilogram in terms of a fundamental constant. The watt balance establishes the kilogram with relation to quantum realisations of the volt and the ohm, and the Avogadro experiment defines a kilogram in terms of a fixed number of atoms. The watt balance concept was originally developed at NPL in 1975 by Dr Bryan Kibble. NPL worked on developing the watt balance until 2008 when the mark II NPL watt balance was transferred to NRC Canada where it is now producing the most accurate measurements of the Planck constant yet made. NPL is also leading a European research project to creating a practical link between results from the new experiments and the current mass scale defined by the IPK. This is a two-fold process where the Planck constant will be initially fixed against the current mass scale as defined by the IPK. After this the unit will be realised by the watt balance and Avogadro experiments and the mass scale will need to be disseminated from these experiments which realise the unit in vacuum, to practical weights in air. They are anticipating completing this research by 2015.

The IPK nominally has zero uncertainty as the mass scale is fixed against it. Relating the scale to naturally occurring constants will assure the long term stability of the scale but, in the short term, it will increase the uncertainty due to the uncertainty in the realisation experiments. There will also be an additional uncertainty of disseminating the scale from vacuum to air. Scientists are aiming to minimise these additional uncertainties to a level of about 3 in 108 which is approximately equivalent to adding the weight of one grain of rice to the overall weight of a car.

Dr Stuart Davidson remarked that: "This anniversary is interesting as it shows just how long this standard for the kilogram has lasted and therefore how good the original choice of material for the IPK was." The kilogram is the last metrological unit to be linked to a physical quantity. Even though the future of the IPK is finite, it should be pleased to have outlasted to other base SI units.

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