Measurement

Mass effect

A better way to clean the world's one true kilogram

IN SEVRES, on the outskirts of Paris, sealed beneath a triplet of bell jars in the laboratories of the Bureau International des Poids et Mesures, sits a small cylinder of platinum-iridium alloy. Put it on a scale, and it would weigh 1 kilogram—which is appropriate, since this lump of metal is not just a kilogram but The Kilogram, the ultimate reference standard for the way the *Système internationale d'unités* (SI or, as it is better known, the metric system) measures mass.

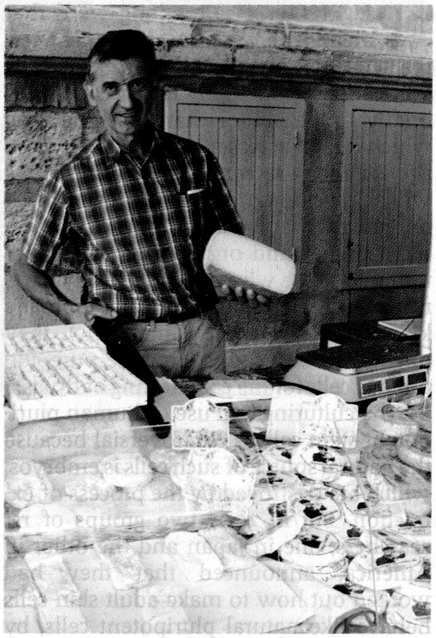
Scientists like the metric system partly for its simplicity—everything is based on powers of ten, which makes calculation easy—and partly for the elegance of its foundations. Of its seven fundamental units, six are defined with reference to unvarying constants of nature: the ampere (electrical current), the candela (luminosity), the second (time), the metre (space), the kelvin (temperature) and the mole (quantity of a substance).

The kilogram is unique in that it is defined by reference to a lump of crude, man-made stuff. Besides aesthetic niggles, that fact leads to an important practical problem. The international prototype kilogram (IPK), the technical name for the cylinder in Sèvres, does not in fact keep a constant mass. Over the years pollutants from the air settle on its surface, causing its mass to rise. Attempts to clean it then cause its mass to fall. As a result, what science understands by a kilogram has varied, but has done so in a way that is, by definition, unmeasurable.

A clean sweep?

The cleaning that attempts to keep the kilogram constant is done by a member of staff at the bureau, using a combination of steam and a chamois-leather cloth soaked in ethanol and ether. But given the sensitivity of modern instruments, which can detect gains or losses of the order of billionths of a kilogram, it must be done properly. Too gentle a rubdown leaves contaminants on the surface. Too vigorous a scrubbing erodes the metal itself.

Worse, the IRK is not the only such cylinder in the world. Dozens of replicas exist in official laboratories in many countries. Each must be cleaned to the same exacting standards if it is to remain a true copy of the French original. In practice, that has often meant shipping the whole lot back to France so that the same person can scrub them all down.



And a kilo of platinum-iridium, please

Now, though, Peter Cumpson and Naoko Sano, a pair of researchers at the University of Newcastle, in England, reckon they have come up with a better way. In a paper just published in *Metrologia*, they describe the results of a method that combines traditional washing with a technique adapted from the chip-manufacturing business, which employs a combination of ultraviolet light and the ozone that such light synthesises from the air to strip pollutants away.

The idea of using ultraviolet light was first proposed back in the 1990s, says Dr Cumpson, but has yet to be adopted ("metrologists", he notes, "are—rightly—rather conservative people"). This latest paper, which reports the results of using the method on strips of platinum-iridium alloy (the IPK and its replicas being far too precious for experimentation), shows that the method does a good job of removing the carbon-based gunk that settles onto the weights from the air. Importantly, says Dr Cumpson, unlike a manual rubdown, his procedure can easily be standardised, and the kit necessary to perform it is cheap and widely available, allowing laboratories around the world to keep their own kilogram replicas clean.

It is not, however, perfect. Besides atmospheric muck, researchers reckon that other things are altering the masses of the world's kilograms. One significant effect, says Dr Cumpson, is contamination with mercury. The likely source is not atmospheric pollutants, but lab accidents. "Say you drop a thermometer and it shatters," he says. "A couple of blobs of mercury fall through the floorboards and evaporate slowly over the years. Some of that mercury is then deposited [on the kilograms]". Unlike the atmospheric junk, which simply encrusts the surface, mercury seeps into microscopic flaws in the cylinders' surfaces created by the polishing process. "Once it gets in, it's in there for good. You can't remove it," says Dr Cumpson.

The missing Planck

It is problems like this—and the fact that the world's kilograms are changing in mass at different rates—that are behind a push to bring the kilogram into line with the rest of the SI, and to define it purely with reference to natural constants. Next year, the International Committee on Weights and Measures will discuss whether to tie it to something called Planck's constant, a number in quantum mechanics that relates the energy level of a photon to its wavelength. A supersensitive electromechanical scale called a watt balance could then be used to define the kilo with reference to Planck's constant, finally liberating the SI from its reliance on fallible artefacts.

That is the theory, at least. But watt balances are fiendishly complicated bits of kit. There are only a handful in the world, a situation that is unlikely to change for the foreseeable future. This means that, although the kilo will in theory be defined by an abstract constant, in practice so-called "transfer standards" will still be needed for the many countries without the nous or the cash to run a watt balance of their own.

Translated into English, the upshot is that outside the most advanced countries, lumps of metal will continue to be used to define the kilo—although they will probably be made of gold, rather than platinum and iridium. These will be susceptible to exactly the same sorts of contamination that plague the current generations of kilogram. Luckily, Dr Cumpson's method ought to work on them, too. ■

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Applicants should write a letter introducing themselves and an original article of about 600 words that they think would be suitable for publication in the Science and Technology section. They should be prepared to come for an interview in London or Washington, DC, at their own expense. A small stipend will be paid to the successful candidate.

Applications must reach us by February 1st. These should be sent to: casement2013@economist.com