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Shrinking kilogram sows mass confusion in labs

Quest for exact kilogram involves counting atoms

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The kilogram is getting lighter, scientists say, sowing potential confusion over a range of scientific endeavours.

The kilogram is defined by a platinum-iridium cylinder, cast in England in 1889. No one knows why it is shedding weight, at least in comparison with other reference weights, but the change has spurred an international search for a more stable definition.

"It's certainly not helpful to have a standard that keeps changing," said Peter Becker, a scientist at the Federal Standards Laboratory in Braunschweig, an institution of 1,500 scientists dedicated entirely to improving the ability to measure things precisely.

The kilogram's apparent loss of 50 micrograms (less than the weight of a grain of salt) is enough to distort scientific calculations.

Mr. Becker is leading a team of international researchers seeking to redefine the kilogram as a number of atoms of a selected element. Other scientists are developing a competing technique to define the weight using a complex mechanism known as the watt balance.

The final recommendation will be made by the International Committee on Weights and Measures, created by international treaty in 1875. The agency keeps the international reference kilogram in a heavily guarded safe in a château outside Paris.

It is visited once a year, under strict security, by the only three people to have keys to the safe. The weight change has been noted on the occasions it has been removed for measurement.

The race is well under way to determine a new standard, although at a measured pace, since creating reliable measurements is such painstaking work.

The kilogram is the only one of the seven base units of measurement that still retains its 19th-century definition. Over the years, scientists have redefined units such as the metre (first based on the earth's circumference) and the second (conceived as a fraction of a day). The metre is now the distance light travels in 1/299,792,458th of a second, and a second is the time it takes for a cesium atom to vibrate 9,192,631,770 times. Each can be measured with remarkable precision, and, equally important, can be reproduced anywhere. The kilogram was conceived as the mass of a litre of water, but measuring that accurately proved very difficult. Instead, an English goldsmith was hired to make a platinum-iridium cylinder that would be used to define the kilogram.

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A total of 80 copies of the reference kilogram have been created and distributed to signatories of the metric treaty. The sometime colourful history of these small metal cylinders underscores how long the world has used the same definition of the kilogram.

Some of the metal plugs were issued to countries that later vanished, such as Serbia and the Dutch East Indies. The Japanese had to surrender theirs after the Second World War. Germany has acquired several, including the one issued to Bavaria in 1889 and the one that belonged to East Germany.

To update the kilogram, Germany is working with scientists from countries including Australia, Italy and Japan to produce a perfectly round one-kilogram silicon crystal. The idea is that by knowing exactly what atoms are in the crystal, how far apart they are and the size of the ball, the number of atoms in the ball can be calculated. That number then becomes the definition of a kilogram.

To separate the three isotopes of silicon, Mr. Becker and his team are turning to old nuclear-weapons factories from the former Soviet Union, where centrifuges once used to make highly enriched uranium are able to produce the required purity of silicon.

"We need so many nines," Mr. Becker said, and the Soviet uranium processors are one of the only places to get them. "With the Russians, we're getting about four of them" – 99.99 per cent pure silicon 28.

A test crystal has been produced, and Dr. Arnold Nicolaus, another scientist at the German standards laboratory, is responsible for measuring whether it is perfectly round. He has measured the crystal in a half-million places to determine its shape.

It's probably the roundest item ever made by hand. "If the earth were this round, Mount Everest would be four metres tall," Dr. Nicolaus said.

An intriguing characteristic of this smooth ball is that there is no way to tell whether it is spinning or at rest. Only if a grain of dust lands on the surface is there something for the eye to track.

But scientists from the United States, England, France and Switzerland say the challenge of calculating the exact number of atoms in a silicon crystal is too imprecise with today's technology, so they are refining a technique to calculate the kilogram using voltage.

"Measuring energy is easier than counting atoms," said Dr. Richard Steiner, a scientist at the National Institute of Standards and Technology in Gaithersburg, Md.

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