47th CIML Meeting Working Document

Addendum 9.5

2012-07-25

The new SI and the impact on legal metrology

Comments received by the ad-hoc OIML Working Group "New SI" are reproduced on the following pages.:

Responses to CIML Resolution No 25 (2011) on the „New SI“

and BIML circular 11 No. 471/WK of 13 December 2011

1. From TC 2 (secretariat: Austria, Richard Goblirsch)

TC 2 provided the following comments.

Switzerland (Philippe Richard, METAS)

My comment is very simple. From the OIML and practical metrology point of view, we can only accept the new definition of the kilogram in the direction recommended by the 24th CGPM if the consequences for users of mass standards at the highest accuracy level are negligible. The impact on practical metrology is minimal if at least the CCM conditions are met (http://www.bipm.org/utils/common/pdf/CCM12.pdf#page=23) AND if a sufficient number of independent primary realization of the definition are simultaneously available and maintained. If this is not the case the redefinition must be postponed to avoid both discontinuities and a too strong degradation of the measurement uncertainty in the calibration chain of mass standards.

The ideal situation would be reached if the present uncertainty for the calibration and measurement capabilities of mass standards at the highest accuracy level remains the same before and after the new definition. This being said, a slight increase of the measurement uncertainty for mass calibrations at the highest accuracy level would be acceptable in exchange of a better long term stability of the kilogram.

P. R. China (Jintao Zhang, NIM)

The new SI definition will imposes no impact on the units of time, length and luminous intensity, but exerts impacts on the units of mass, electric current, temperature and amount of substance. Referring to Draft Chapter 2 for SI Brochure of CCU, we observe that the new definition will have a major impact on the unit of mass. The OIML shall have consideration on the guide of the delivery of the new unit, the available transfer device, the new role of the used national mass prototypes. There are a number of watt-balances among NMIs. According to the new definition, watt-balances will serve as the primary standard of the unit of mass. There appears a question with the consistency and the long-term stability of the values given by the different the primary watt-balances. We recommend that OIML shall start to solicit to the communities of the international metrology, the variant disciplines of science and technology for a preparation of an international recommendation with the use and the kilogram-delivery by the primary watt-balances. Next, if watt-balances goes commercially after the new definition, OIML shall consider to prepare an recommendation for manufacturing. Third, not each NMI will equip watt-balance. OIML shall work with CCU to make selection of the secondary standard to the primary watt-balance standard, to define the role of the used national primary prototypes, to define the delivery of the new kilogram from the watt-balance standard to the secondary standard. According, the corresponding recommendation shall be considered by OIML. Fourth, OIML shall work with CCU about the consistency between the new kilogram and the new mole. A new recommendation may be necessary for that consistency.

For kelvin, the new definition will open the way for the direct measurement of thermodynamic temperature at the range above 600 °C. A number of recommendations need to cover the delivery of the thermodynamic temperature scale in high temperature ranges, the interpolation procedure and device for the high thermodynamic temperature scales, the inconsistency of the interpolation methods for different sub-ranges of temperature, the manufacturing of absolute radiation thermometers, etc. The similar request is applied for the low temperature scale ranging from 1 K to 1mK.

United States (Ambler Thompson, NIST)

The US fully supports the proposed changes to the SI when the scientific results are judged sufficient. The final decision is to be made by CGPM considering all the benefits of a redefined SI.

We have concern that current claimed mass uncertainties do not reflect the observed instabilities in mass artifacts. OIML through R111 and class E1 weights places the most stringent uncertainty requirements on the mass metrology system, we believe that it would be most constructive if OIML could evaluate revising R111 with what we would consider more realistic uncertainties of mass in a redefined SI.

Japan (Matsumoto Tsuyoshi, NMIJ)

We consider that an enlightenment activity for the legal metorology community is necessary in order to facilitate understanding of the basic concept of new SI.

South Africa (Jaco Marneweck, NRCS)

The central philosophy of the impending redefinition of the SI Units is to instead of defining an SI unit per se, the CGPM will specify exact values for a set of fundamental constants which will set the scale for the SI units. This would enable new worldwide levels of consistency and accuracy and rid the system of its dependence on a physical artefact, the international prototype kilogram. The kilogram, the ampere, the kelvin and the mole, will be redefined in terms of invariants of nature; the new definitions will be based on fixed numerical values of the Planck constant (h), the elementary charge (e), the Boltzmann constant (k), and the Avogadro constant (N_A), respectively.

The mass of the international prototype kilogram (the original platinum-iridium prototype), appears to have drifted a few parts in 10^8 in the course of the past 100 years. In the new system, the kg will be defined by fixing the value of the Planck constant, h, at 6.626 06X x 10^{-34} joule second. To achieve this a device called a watt balance is used, which measures the force required to balance a 1 kg mass artefact against the pull of Earth's gravity by monitoring the voltage and current (hence the name "watt") involved in doing so.

The CGPM has called for further reductions in measurement uncertainty before the "new SI" can be implemented; specific to the kilogram a target figure of 2 x 10^{-8} has been set. The typical current relative uncertainty for a watt balance is in the order of 4 x 10^{-8}. Watt balance devices are either operating or under development in Canada, Switzerland, France, China, and at the BIPM. The typical expanded uncertainty of for a 1 kg mass standard is a few x 10^{-7}, the adoption of the new SI unit for the kilogram thus will not directly influence the Legal Metrology fraternity in South Africa, but may influence scientific metrology in the country. The only inherent danger is when the "new"

kilogram (realise as per definition) differ from the "old" kilogram (the original platinum-iridium prototype), how will this difference be handled?

2. From TC 9 (secretariat: United States, John Barton)

TC 9 received one response from Canada which indicated that there were no comments to pass on to the ad-hoc group.

3. From TC9/SC3 (secretariat: Germany, Michael Borys)

TC9/SC3 received comments from 6 countries: Switzerland, UK, Slovenia, Romania, Bulgaria and Germany. It is referred to the separate table of comments attached.

4. From TC11 (secretariat: Germany, Joachim Fischer)

TC11 responded that the inquiry among its P- and O-members regarding the revision of the International System of Units has resulted in no additional questions or comments, and that, in summary, the legal metrology community - regarding thermometry issues - seems to be well prepared for the new definition of the temperature unit kelvin.

5. From CIML members

Besides the countries that provided comments to one of the above TCs, five countries (Cuba, Cyprus, Kazakhstan, Poland, Slovakia) either responded that they agree with the proposals of the BIPM for a „New SI“, or that they have no comments. In addition, some countries provided the following responses.

Australia (Graham Harvey, NMI):

On balance, my view is that this matter is outside the scope of OIML except to the extent that it impinges on the calibration of OIML standards of mass. In my opinion, those OIML members from NMIs that also adhere to the Metre Treaty should make other comments directly through the appropriate BIPM consultative committees or directly.

In a previous meeting, you made the point that the least uncertainty that could be achieved under the new SI was greater than currently available and would not be adequate to verify class E1 weights. However, I understand that the previous least uncertainty did not include the hidden uncertainty of the International prototype kilogram. It was suggested at our last meeting with BIPM that, with a reasonable estimate of the latter, the final least uncertainty was about the same.

France (Corinne Lagauterie, FR)

If we take as guaranteed that no decision will be taken by the CGPM before there is a sufficient level of coherence, confidence and sufficient number of ready to use "standard" weights available, there should be no problem. Of course these conditions are critical. I suggest also to ask manufacturers of mass, I mean of the of highest class, about their opinion.

TC 9/SC 3 – Comments on New SI, Redefinition kg

Country	NMI/DI	Name	Comment
Switzerland	METAS	P. Richard	From the OIML and practical metrology point of view, we can only accept the new definition of the kilogram in the direction recommended by the 24th CGPM if the consequences for users of mass standards at the highest accuracy level are negligible. The impact on practical metrology is minimal if at least the CCM conditions are met (http://www.bipm.org/utils/common/pdf/CCM12.pdf#page=23) AND if a sufficient number of independent primary realization of the definition are simultaneously available and maintained. If this is not the case the redefinition must be postponed to avoid both discontinuities and a too strong degradation of the measurement uncertainty in the calibration chain of mass standards. The ideal situation would be reached if the present uncertainty for the calibration and measurement capabilities of mass standards at the highest accuracy level remains the same before and after the new definition. This being said, a slight increase of the measurement uncertainty for mass calibrations at the highest accuracy level would be acceptable in exchange of a better long term stability of the kilogram.
UK	National Measure-ment Office	M. Awosola	We think there is still work to be done to inform and educate the legal metrology field, manufacturers, test labs and end users about the change and ensure that the new SI remains understandable to all those who need to use it.
Slovenia	MIRS	R. Lapuh	We just received a circular letter from Mr. Kool, where he is asking us to respond to the same issue directly to him or to Dr. Schwartz till 24. February 2012. In order not to duplicate our work, we will respond only to his call with a comprehensive views from all our team.
Romania	BRML	D. Dinu	Please be informed that Romania has no comments on the "New SI" and the redefinition of the kg.
Bulgaria	BIM	D. Ivanova	I hereby inform you that we have no comments on the “New SI” from the perspective of legal metrology.
Germany	PTB	M. Borys	For legal metrology, it is essential that no problems will be caused in the dissemination chain after a revision of the SI and the proposed redefinition of the four SI base units kilogram, ampere, kelvin and mole in terms of fundamental constants. As regards possible consequences for legal metrology, the redefinition of the kilogram is the most critical one. In the scientific community of mass metrologists it is generally accepted that continuity in practical mass determination is preserved after the new definition is introduced and no serious changes in the calibration chain of mass standards will occur if the requirements of the CCM recommendation G1 (2010) are fully met (http://www.bipm.org/utils/common/pdf/CCM12.pdf). If the realisation uncertainties and the consistency requirements are larger than those recommended by the CCM, the best uncertainties of the CMC tables would have to be significantly increased and corresponding larger uncertainties would be attributed to the reference standards of the authorities and calibration laboratories, mass standards with relative standard uncertainties $< 4 \times 10^{-8}$ – as presently offered by NMIs for applications with highest requirements – would no longer be available and (accredited) industrial calibration laboratories would no longer be able to calibrate class E_1 standards. The NMIs themselves would have to satisfy the needs for class E_1 weights in a country, which would require more

			equipment and personnel and, thus, costs in many NMIs. If the present needs for class E_1 weights cannot be satisfied, the number of class E_2 weights may decrease as well. Such weights are required by law for verifying or calibrating class I weighing instruments. Most weighing instruments cover several decades of mass values. Because goods of masses in this range are weighed with such instruments, their verification/calibration requires much higher accuracy than a particular object. This is one of the reasons why mass standards must be more accurate by orders of magnitude than the objects to be weighed. A proposal to adopt a 'conventional value' of the kilogram was proposed (Mills et al. 2005, Metrologia 42 71–80), that would allow an early redefinition of the kilogram, even if the uncertainties of the Avogadro and watt balance experiments have not yet attained the recommended level. This concept would establish two parallel kilograms with different values and uncertainties. Even though a similar situation was established for the electrical units, because new techniques allowed links of the volt and the ohm to fundamental constants and better accuracies than the ampere definition of 1948, this proposal should be rejected, because on the occasion of redefining the SI units, the creation of a non-SI 'conventional kilogram' in parallel to an SI kilogram having a minor practical meaning is unsatisfactory. The introduction of a 'conventional kilogram' would disconnect the world of fundamental constants and the SI from the world of practical metrology. In legal metrology, conventional mass (OIML D 28, OIML R 111) is derived directly from the mass. The traceability of mass standards to the SI is required in legal and industrial metrology (ISO 17025, OIML D2, OIML R111). If in the future Avogadro and watt balance experiments arrive to consistent results with rel. uncertainties close to 10^{-8}, withdrawing the conventional kilogram would perhaps imply substantial corrections to all mass standards, other standards related to the kilogram and even replacements of some OIML class E_1 weights. As an alternative, instead of different units, the adoption of two different quantities of mass has been proposed, where the 'usual mass' is distinguished from an 'International mass' or 'Practical mass' (Quinn 2010, CCM Working Document CCM/10-5/rev1). Similar to the situation with two parallel kilograms, two parallel quantities of mass would lead to confusion and misunderstandings, for example, when related quantities, such as density, are derived from the mass. Another argument is that both, the concept of different units and different quantities of mass, are rendered superfluous as soon as the Avogadro and watt balance experiments have reached sufficiently low uncertainties, which can be expected in the foreseeable future. Also in legal metrology, it is important to initiate awareness about the new definitions of the SI base units and possible consequences. In principal, the understanding of the new definitions should not require a much higher education than that supplied by primary and secondary schools. Therefore, it should be considered that in the Resolution 1 (2011) the CGPM invited "the CIPM to continue its work towards improved formulations for the definitions of the SI base units in terms of fundamental constants, having as far as possible a more easily understandable description for users in general, consistent with scientific rigour and clarity".

CECIP Position on possible future revision of the International System of Units-SI

CECIP, the European Weighing industry association,

- represents 700 European manufacturers of weighing instruments from 15 countries with 50000 employees plus 4000 - 5000 micro companies with additional 10000 employees, with a turnover of more than 3 billion Euro, which is more than 50 % of the world trade volume for weighing instruments;

- is a liaison organization of the International Organization of Legal Metrology (OIML), and participates actively in several OIML Technical Committees and Subcommittees, amongst them TC9/SC1 “Non-automatic weighing instruments”, TC9/SC2 “Automatic weighing instruments” and TC9/SC3 “Weights”;

- appreciates the invitation of the General Conference on Weights and Measures (CGPM) to comment on the "Possible future revision of the International System of Units, the SI" as an important user community, based on Resolution 1 of the 24th CGPM in 2011.

CECIP wishes to provide some comments on the possible "New SI" for consideration by the CGPM.

While a revision of the SI may be desirable from the point of view of fundamental physics, CECIP does not see a need for a "new SI" at the moment from a practical point of view. On the contrary, CECIP is deeply concerned that a premature redefinition of the existing SI base units, especially that of the kilogram, could negatively affect practical mass measurements, at least at the high-precision level.

The practical system of mass metrology, based on the International Prototype Kilogram (IPK), is well established, worldwide accepted, and meets all demands of the user community of weighing instruments and mass standards. The current definition has up to now never suffered from any limitations due to a possible, never proven drift of the IPK. It has quite successfully guaranteed up to now, that - all over the world - high-precision mass standards and weights of accuracy classes E2, E1 and even better are calibrated and used in the global market without any problems.

Can the CGPM or the CIPM guarantee that this high level of worldwide confidence and agreement of calibrated mass standards be kept with a redefined kilogram? Is it guaranteed that calibration certificates issued in different Member States will remain consistent, as it is the case now? And is it guaranteed that a redefined kilogram will not "jump" by more than $4 \cdot 10^{-8}$ which is the smallest relative measurement uncertainty provided in calibration certificates issued by accredited mass laboratories at the moment?

CECIP is concerned that a very successful, broadly accepted, well-functioning, worldwide metrology system, as the current SI is, might be jeopardized by an overhasty, premature decision for a "new SI" that has neither a sound experimental basis nor practical benefits. Considering the extremely large importance of weighing instruments and mass standards used in trade and industry, and also in daily life, the possible practical consequences and negative implications of a premature or even wrong decision could be tremendous. Bearing in mind the risk that certain countries could even turn back to a national metrology policy, if the SI and the international metrology system make negative headlines, which might have political consequences.

Finally, CECIP has reservations as to the proposed new definition relating the kilogram back indirectly to an "anonymous" fundamental constant "*h*" that is not very well known by the general public, even not by well-educated people. A "new SI" should be well-understandable and plausible for the general public in order to keep the currently high level of acceptance for an international system of units.

In summary, CECIP representing or being in close touch with an important users' community of the SI, considers the proposed "new SI" as not yet sufficiently thought-through and not yet acceptable from the practical point of view.
CECIP would, in the future, be supportive of a "new SI" in general, and a redefined kilogram in particular, in case it is absolutely ensured that the high level of worldwide consistency and acceptance of calibration certificates issued by national metrology institutes or accredited calibration laboratories be kept or improved, and if the SI units be redefined in a comprehensive, plausible manner.

As a relevant stakeholder, CECIP welcomes with the possibility to give comments on this very important item.
CECIP encourages the relevant authorities to keep the industry involved in any future discussions and developments on this issue.

Best regards,

Veronika Martens

Vincent van der Wel

Brussels,15 May 2012