

Bureau International des Poids et Mesures

Consultative Committee for Units (CCU)

Report of the 16th meeting
(13–14 May 2004)
to the International Committee for Weights and Measures



Comité international des poids et mesures

Bureau
international
des poids
et mesures

Organisation
intergouvernementale
de la Convention
du Mètre

Note:

Following a decision made by the International Committee for Weights and Measures at its 92nd meeting in October 2003, Reports of meetings of Consultative Committees will henceforth be published only on the BIPM website in the form presented here.

Full bilingual printed versions in French and English will no longer appear.

T.J.Quinn,
Director BIPM,
November 2003.

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR UNITS

as of 13 May 2004

President

I.M. Mills, International Union of Pure and Applied Chemistry [IUPAC], Commission STU.

Executive Secretary

C. Thomas, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

Centro Español de Metrología [CEM], Madrid.

International Astronomical Union [IAU].

International Commission on Illumination [CIE].

International Commission on Radiation Units and Measurements [ICRU].

International Electrotechnical Commission [IEC], Technical Committee 25.

International Federation of Clinical Chemistry and Laboratory Medicine [IFCC].

International Organization for Standardization [ISO], Technical Committee 12.

International Organization of Legal Metrology [OIML].

International Union of Pure and Applied Chemistry [IUPAC], Commission STU.

International Union of Pure and Applied Physics [IUPAP], Commission SUN-AMCO.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology [NMIJ/AIST], Tsukuba.

National Physical Laboratory [NPL], Teddington.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig and Berlin.

State Committee of the Russian Federation for Standardization and Metrology [Gosstandart], Moscow.

M. Himbert.

T.J. Quinn.*

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

* His election as personal member was ratified by the CIPM at its 93rd meeting in 2004.

1 OPENING OF THE MEETING; APPOINTMENT OF THE RAPPORTEUR; APPROVAL OF THE AGENDA

The Consultative Committee for Units (CCU)* held its 16th meeting at the International Bureau of Weights and Measures (BIPM), at Sèvres, on 13 and 14 May 2004.

The following were present: J. Bastie (CIE), C.A. Borghi (IEC/TC 25), N. Capitaine (IAU), R. Dybkaer (IFCC), J. Flowers (NPL, IUPAP/SUN-AMCO), K. Fujii (NMIJ/AIST), M. Himbert (BNM-INM), A. Leitner (OIML), T. López (CEM), Zuliang LU (NIM), I.M. Mills (President of the CCU, IUPAC), T.J. Quinn (Director Emeritus of the BIPM), B. Siebert (PTB), B.N. Taylor (NIST), A.J. Wallard (Director of the BIPM), A. Wambersie (ICRU), R.L. Watters (NIST), A.J. Thor (ISO/TC 12), Yan ZHAO (AQSIQ).

Also present: P. Giacomo (Director Emeritus of the BIPM), D. Le Coz (BIPM), and C. Thomas (Executive Secretary, BIPM).

Apologies were received from S.M. Seltzer (ICRU) and B.W. Petley (IUPAP/SUN-AMCO).

Prof. Mills opened the meeting mentioning the presence of two Directors Emeritus of the BIPM, Prof. Giacomo and Dr Quinn, plus one active Director of the BIPM, Prof. Wallard. Then he welcomed the newcomers: Dr Thomas, Executive Secretary of the CCU since the retirement of Prof. Martin from the BIPM, Dr Capitaine replacing Dr Débarbat representing the IAU, Dr Watters from NIST, Prof. Wambersie from ICRU, Dr Zuliang Lu from NIM, Dr López from CEM, and Mrs Le Coz from the BIPM.

Dr Flowers was appointed rapporteur, to be assisted by Dr Thomas.

Prof. Mills reminded the CCU of their responsibilities as agreed in the previous report, and that the main work of this meeting was to be the revision of the SI brochure to prepare the 8th edition. Drafts and comments for several chapters were among the working papers for this meeting.

2 REPORT OF THE 15th CCU

The report of the 15th meeting of the CCU was approved. It was noted that following a decision taken by the CIPM at its 92nd meeting in October 2003, reports of future meetings of Consultative Committees are to be published only on the BIPM website, and that full bilingual printed versions in

* For the list of acronyms, [click here](#).

French and English will no longer appear. The [report of the 15th meeting of the CCU](#) is available on the BIPM website.

3 CGPM REPORT BY THE PRESIDENT

The Resolution concerning the decimal marker was passed with no votes against at the last CGPM meeting in October 2003. It constitutes Resolution 10 of the 22nd CGPM, stating that “the symbol for the decimal marker shall be either the point on the line or the comma on the line”. Moves are underway to bring ISO and IEC standards in line with this.

4 8th EDITION OF THE SI BROCHURE

This meeting will consider the next edition (8th) of the SI brochure. Drafts for various parts had been submitted by a number of authors, as agreed at the previous meeting. The main work of this meeting was the detailed review and editing of these drafts. This was done in part by the Executive Secretary updating the draft documents, which will provide a record of the editing and, in part, by the identification of authors for drafts of various sections as given below.

4.1 The BIPM and the Convention du Mètre

The BIPM staff will update this section.

4.2 Preface

Prof. Wallard and Prof. Mills will draft this section after the preparation of the rest of the document, as stated in the report of the 15th meeting.

4.3 Chapter 1 - Introduction

A draft version of Chapter 1 by Prof. Mills (document CCU/04-01)* was considered by the meeting. It is organized, as agreed at the 15th meeting, as a tutorial discussion on quantities and units, noting the advantages of a coherent system. It also contains a detailed discussion on dimensions and prefixes, the topics on “Units in the framework of general relativity” and “Legislation on units” remaining unchanged.

At the 15th meeting, it had been said that “the historical note was not an engaging preamble and should be moved to become an introduction to Appendix 1”. Prof. Mills had thus deleted it from his draft Chapter 1. This point was reconsidered at the 16th meeting, and a consensus was reached that we do not really want to begin with the history, but neither do we wish to banish it to an appendix as the historical note is concerned with laying the background. It was thus decided it should remain in Chapter 1. In his new version of Chapter 1 dated July 2004, Prof. Mills proposed to place the historical note at the end (Section 1.8).

Prof. Thor suggested that the quantities should be mentioned before the units as this represented the logical order. Dr Taylor supported his view. Prof. Mills preferred his order as this was consistent with history, but will consider eventual changes.

It was agreed that a marginal note with a reference to the *International Vocabulary of Basic and General Terms in Metrology* (VIM) should be introduced in Section 1.1 “Quantities and units”, which would give the definitions of the terms “quantity” and “unit”.

A discussion ensued concerning the word “value” in the sentence, “The unit is simply a particular value of the quantity concerned...”. Dr Dybkaer and Prof. Giacomo explained that the unit is simply a particular instance or example of the quantity concerned. The word “example” was chosen instead of “value”. Other various changes to the text were made with the agreement of the meeting.

Prof. Mills offered a redraft of section 1.2 as there were a number of objections to references to the International System of Quantities (ISQ) and the unpublished ISO 80000 document. Dr Quinn pointed out that to some, ISQ looks like ISO trying to standardize physics; it appears that the SI is limited to ISQ quantities. He also noted that it takes many years to change an ISO document. If there were a reference to a system of quantities he would prefer “international system of quantities” i.e. in lower case. It was agreed that in the new draft it would be preferable to downplay the ISQ.

It was generally agreed that “quantity of dimension one” is technically preferable to “dimensionless”, but Prof. Giacomo disagreed. Prof. Mills also preferred dimensionless, as this is common parlance. The compromise sentence “... Such quantities are described as being *dimensionless*, or alternatively as being *of dimension one*.” was agreed. The paragraph on vectors and scalars was thought to be unclear and was removed following a vote.

Various small changes of text were made in Section 1.4 “Coherent units” and in Section 1.5 “SI units in the framework of general relativity” with the agreement of the meeting.

The part “Legislation on units” will be moved to the end of Chapter 1, thus becoming Section 1.7.

* Working documents submitted to the CCU at its 16th meeting are on restricted access to members of the CCU.

A new section of Chapter 1, Section 1.6 on units for certain quantities that cannot yet be expressed in terms of SI units, had been drafted by Dr Quinn. The wording of this section was not agreed at the meeting, and Dr Dybkaer, Dr Quinn, Dr Siebert, and Dr Wielgosz (Chemistry section, BIPM) were asked to reword it and find examples. This new section is being included to consider important problems in human health and safety related to specific biological effects that cannot yet be defined in terms of the SI units (document CCU/04-16).

4.4 Chapter 2 - SI units

The draft Chapter 2 by Prof Mills (document CCU/04-05) was considered by the meeting.

Section 2.1.1 “Definitions” included a second paragraph dealing with the difference between the definition of a unit and its realization, as decided at the 15th CCU meeting. Dr Quinn and Dr Taylor were not satisfied with this text, and wanted to emphasise the point that a unit may be realized in a way different from that implied by the definition. Prof. Mills agreed. Dr Quinn and Dr Taylor agreed to draft a new version, which would also include both the role of fundamental constants, and the inter-relationship between the base units.

The question of the spelling of words such as “realisation”, with an “s” or a “z” was discussed. Dr Quinn confirmed that the rule applied to English BIPM texts was to use a “z”.

Additional comments beginning “Note that the effect of this definition is to fix the quantity...”, given after the official definitions of units, were approved by the meeting. Dr Flowers pointed out that they should read “fix *the value* of the quantity...”, and this was accepted. The meeting agreed that a note of this type should accompany all the definitions even though in some cases it could be considered tautological.

Prof. Borghi said that logically, the second should be defined before the metre. The meeting recognized that this is the case but agreed to continue with the traditional order.

Prof. Thor objected to the use of the expression “chemical amount” in Section 2.1.1.6 entitled “Unit of amount of substance (mole)”. Prof. Mills agreed to reword the corresponding paragraph.

Dr Bastie objected to the wording of the note added after the definition of the candela in Section 2.1.1.7 “Unit of luminous intensity (candela)”, and agreed to reword it.

Various additional small changes to the text were made with the agreement of the meeting.

About Section 2.1.2 “Symbols for the seven base units”, Dr Quinn pointed out that the introduction of the new table “Base quantities in the SI, with their symbols and dimensions” in Chapter 1 meant that the table traditionally labelled and known as “Table 1” was no longer the first table. The agreed solution was to leave the table in Chapter 1 unnumbered so that Table 1 still listed the SI base units. The usual symbols of the base quantities were added to Table 1.

The meeting agreed to change the title of Table 2 of Section 2.2 “SI derived units, and coherent derived units” to read “Examples of coherent derived units in the SI expressed in terms of base units”. The following modifications were made to Table 2 of the 7th edition of the SI brochure:

- The derived quantity “density, mass density” becomes “mass density”.

- The derived quantity “concentration (of amount of substance)” becomes “amount concentration, concentration”.
- The derived quantities “surface density”, “mass concentration” and “relative permeability” are added.
- The usual symbols of the derived quantities are added.

There was disagreement over the name for m^{-1} ; the meeting voted to retain “reciprocal metre” as this was agreed to be common practice among spectroscopists, but some preferred “inverse metre” and some “metre to the power minus one”, which Prof. Himbert pointed out, is closest to the French version.

Dr Taylor pointed to the rule that “per second squared” and “per square metre” is correct; i.e. that the square or cubic comes before the unit in the case of area and volume. It was agreed that the usage in Table 2 must be consistent with the rules in Chapter 5.

The derived quantity “catalytic activity”, to be expressed in “katal”, was added to Table 3, and the title of the table was changed to read “Coherent derived units in the SI with special names and symbols”. A note was attached to this table, specifying that the SI prefixes might be used with any of the special names and symbols, pointing out, however, that when this is done, the resulting unit will no longer be coherent.

It was decided that Prof. Wambersie would draft a note applying to the “gray” and the “sievert” in line with Recommendation 2 of the CIPM 2002 (PV, 70, 2003) entitled “Dose equivalent”, and would also check the wording of the expression “activity referred to a radionuclide” in Table 3.

Prof. Giacomo suggested adding a note about the special names “hertz” and “becquerel”, both expressed as the reciprocal second, stating that the hertz was used only for periodic phenomena and the becquerel for stochastic processes in radioactivity.

There was a discussion on the use of spaces rather than half-high dots as the separator in products of units. Prof. Thor explained that the half-high dot is more readable and is preferred by ISO and IEC. Dr Thomas pointed out that a problem arose with publishing on the web non-pure html characters, such as the half-high dot and the capital omega “ Ω ”, which should be replaced by images. Although either is allowed, spaces would preferably be used in the text.

Table 4, “Examples of SI derived units whose names and symbols include SI derived units with special names and symbols”, and content remained unchanged, except that one extra line is added for the derived quantity “catalytic activity concentration”.

A discussion was stimulated by the proposed text after Table 4 in document CCU/04-05. Prof. Giacomo pointed out that the name of the unit implies nothing about the quantity itself. For instance, one should mention on measuring instruments the quantities that are measured, and not only the units. He also insisted that different quantities have different units even when they have the same dimension, and the same unit names, because units are instances of the quantities; for example, energy and torque have different units with the same name (joule, or newton metre).

Dr Watters said that, in practice, the SI units of energy and torque would always be quoted respectively as the joule and the newton metre, although they have the same dimension. Dr Siebert

stated that we should use the freedom given us by these units to aid in understanding the origin of the terms.

Prof. Mills finally decided he would redraft the text between Table 4 and Section 2.2.3.

Section 2.2.3 on “Units for dimensionless quantities, quantities of dimension one” was then considered. It was decided that the radian and the steradian are well placed here. The neper, however, should not be mentioned here. Prof. Mills would amend this part of document CCU/04-05.

It was agreed that a subgroup composed of Dr Bastie, Dr Dybkaer, Dr Quinn, Dr Siebert, and Prof. Wambersie would draft a new section, Section 2.2.4, on “Units for physiological quantities”.

4.5 Chapter 3 - Decimal multiples and submultiples of SI units

Prof. Mills presented a new version of Chapter 3 (document CCU/04-12). This was largely the same as the old version, but with the incorporation of some comments that had been received.

Dr Taylor suggested that we should use NIST SP 330, p. 14, as a model for the marginal note on binary multiples and this was agreed. Prof. Thor gave a reference, IEC 60027-2:2002 which gives the names and symbols of the binary prefixes; for example, 2^{10} bytes should be designated as 1 kibibyte, leading to the algebra $1 \text{ KiB} = 2^{10} \text{ B} = 1024 \text{ B}$.

Prof. Mills drew attention to the fact that he had reordered the prefixes of Table 5 “SI prefixes” to give the smallest at the top for the multiples, and the biggest at the top for the sub-multiples. There was some approval and no strong dissent to this.

Further minor changes of text were made with the agreement of the meeting.

4.6 Chapter 4 - Units outside the SI

Prof. Mills presented a new version of Chapter 4 (document CCU/04-02). He introduced the draft, commenting that he had no desire to deprecate some people’s preference for non-SI units. He would point out the advantages of the SI and leave it at that. He asked for comments on the current list. Dr Taylor pointed out that some might take our lack of firmness as a license to continue poor practice. Prof. Mills pointed to paragraph 3 of the introduction to Chapter 4, which discussed the preference for correct SI usage.

The arrangement of tables in Chapter 4 was discussed. Prof. Thor did not agree to the move of the litre and tonne from Table 6 to Table 8. Prof. Mills pointed out that this was not a downgrading but a rearrangement.

Dr Flowers pointed out that units based on volume and area have unduly large steps because the rule of three in prefixes becomes a rule of six or nine for squared and cubed units. Dr Quinn suggested a regrouping by usage. The tonne, litre, and hectare are widely used and should move to Table 6. The barn, bar, ångström, nautical mile, decibel, and neper are of specialist use and should therefore be in Table 8. There was some general agreement for this. Prof. Thor said he could accept this but wanted the gon to be included in Table 8. Dr Leitner pointed out that the gon is legal for use in the European

Union whereas the ångström is not. He noted also that the unit “millimetre of mercury” is legal for the expression of blood pressure, but is not in the brochure. Prof. Mills agreed to mention the gon in the footnote relevant to the degree in Table 6, and to include the millimetre of mercury in Table 8.

It was finally decided that Table 6, named “Non-SI units accepted for use with the International System”, should contain the non-SI units that are universally used in all countries, while Table 8 renamed “Other non-SI units” would contain non-SI units that are used by specialized groups. In practice:

- The minute, hour, and day (time), the degree, minute, second (plane angle), the litre (volume), and the tonne (mass) should be retained in Table 6.
- The neper, bel, and decibel (logarithmic ratio quantities) should be moved to Table 8.
- The are and hectare (area) should be moved from Table 8 to Table 6.
- The ångström and nautical mile (length, distance), the barn (area), the knot (velocity), and the bar (pressure) should be retained in Table 8.
- The millimetre of mercury (pressure) should be added to Table 8.

The footnotes relevant to Table 6 and 8 should be modified appropriately.

Prof. Mills reported considerable correspondence on the subject of the symbol for the nautical mile. There is no internationally agreed symbol, but “M” and “NM” are in common use. It was agreed to include the symbol “M” in Table 8, and to give both symbols in a footnote. In line with this, the symbol “kn” was added in Table 8 for the knot, though again there is no international agreement.

Prof. Mills presented a new version of the discussion of the bel and neper; a version revised compared to that in CCU/04-02. Prof. Giacomo pointed out that the bel and neper are not units but special names for quantities expressed as logarithmic ratios. Prof. Thor expressed his preference for the old wording. Dr Siebert also considered it as inconsistent to use the neper and the bel, but since they are widely used, one should realize that any attempt to discourage their use would be futile. However, the new edition of the SI brochure should contain a note stating that in reporting levels a complete definition shall be provided. Prof. Giacomo added that these are the first logarithmic scales we have to deal with, but there will unavoidably be others in future, especially in biology. Prof. Mills agreed to redraft the footnotes relative to the neper and the bel in the light of comments.

Dr Quinn suggested that Table 7, “Non-SI units accepted for use with the International System, whose values in SI units must be obtained experimentally”, should be extended to cover natural and atomic unit systems. Prof. Himbert agreed and it was decided to form a subgroup composed of Dr Flowers, Prof. Himbert, and Dr Taylor to consider extending Table 7 and improving the related text.

In the draft of Chapter 4 dated July 2004, sent by Prof. Mills for consideration by the members, Table 7 included the natural units of speed, action, mass, and time, and the atomic units of charge, mass, action, length, energy, and time, together with the experimental non-SI units the electronvolt, the dalton, the unified atomic mass unit, and the astronomical unit. Dr Capitaine said that a reference should be given for these four units and proposed to provide the most recent reference for the SI value of the astronomical unit.

Table 9 becomes “Other non-SI units associated with the CGS and the CGS-Gaussian system of units”, but its content will be unchanged. Dr Bastie would, however, review the lines about “luminance” and “illuminance”. It was further decided that a text about the relationship between the CGS-Gaussian system and the SI would be considered as a new Appendix to the brochure (see Section 4.8).

Dr Quinn said there was no need for Table 10 “Examples of other non-SI units” because this list is very incomplete and corresponds to units that are not recommended for use. Prof. Mills objected saying that this Table was in previous editions and often proved to be useful. Dr Quinn suggested keeping a table of conversion factors separate from the SI brochure and available on the Internet. Dr Watters declared that several such websites exist, but are not reliable. General agreement was reached that this should be maintained by the BIPM as part of its website, and under the responsibility of the CCU. Prof. Wallard took note of this decision.

4.7 Chapter 5 - Writing unit symbols and names, and expressing the values of quantities

The meeting considered the text by Dr Taylor (document CCU/04-11).

Prof. Mills thought the text too long and detailed; he did not want it to swamp the brochure. Dr Taylor pointed out that this is the only place where these rules are brought together, and that if included in the brochure they would carry the endorsement of CIPM. Prof. Giacomo said that we were entering here into a field, which is more the province of ISO. Dr Quinn suggested that we should consider to whom the brochure was addressed and wondered if we should favour the principles or examples. There was general consensus that examples are essential and should be given in a number of marginal notes attached to a shorter text. Prof. Mills proposed that Dr Quinn, Dr Siebert, and Dr Taylor join him in June for drafting a new version.

Dr Taylor, Dr Siebert, and Dr Dybkaer expressed their opinion that a reference to the *Guide to the expression of uncertainty in measurement* (GUM) be given in section 5.3.5. In this regard, Dr Dybkaer said that the GUM will be unchanged but there will be supplements providing extensions and clarification.

There was a discussion on the example of “molecular concentration” in Section 5.3.2 where the use of a unit such as molecules/m³ was disallowed. Prof. Mills said he thought this usage should be acceptable. Prof. Thor and Dr Dybkaer disagreed strongly.

4.8 Appendices

It was agreed that chronological ordering of the resolutions in Appendix 1 “Decisions of the CGPM and the CIPM” was preferable, but that there should be a subject index to facilitate locating particular decisions. The intention is that someone wishing to find a specific resolution should be able to do so quickly and easily, and should also be able to locate subsequent decisions on the same topic. Prof. Mills, Dr Thomas and Mrs Le Coz will take care of this.

It was also agreed that there was no need for an appendix on practical realization of units as the material was changing on a timescale too rapid for the brochure to be kept up to date. Dr Quinn and Dr Taylor would draft a paragraph at the end of Appendix 1 to refer to practical realizations, and the Resolutions detailed in the Appendix 2 of the 7th edition of the SI brochure would be transferred into Appendix 1 of the new edition.

Prof. Wallard would ensure that the list of Resolutions was up to date, and bring up at the CIPM the idea that the material on realizations should be a separate web document maintained on the BIPM website, under the responsibility of the appropriate Consultative Committee.

A new Appendix 2 on the “Relationship between the CGS-Gaussian system and the SI” (see Section 4.6) will be drafted by Prof. Mills.

5 THE “UNO” AS A NAME FOR THE UNIT OF DIMENSION ONE

As agreed at the previous meeting, opinions on the introduction of the “uno” as a name for the unit of dimension one had been widely solicited. Prof. Mills reported that the responses had been almost entirely negative and that he recommended dropping the idea. There was general acceptance of this proposal.

6 TIMETABLE FOR THE NEXT STEPS

Prof. Mills undertook to produce a draft of the entire brochure with the help of BIPM staff by the end of June 2004. This would be posted on the CCU restricted-access website and members could comment (by email to Prof. Mills and to Dr Thomas) by the end of August 2004. The draft would then be presented to the CIPM at the start of October 2004. If only minor changes were required, Prof. Mills proposed an editorial meeting composed of four or five individuals in February 2005 rather than reconvening the CCU. It is hoped that a French version could then be produced in time for a planned publication date of Summer 2005.

The 8th edition of the SI brochure will be published in paper form as a full bilingual (French and English) text including the Preface, the five Chapters, and the two Appendices. The same information will be made available in the form of a pdf file and of a searchable hypertext on the BIPM website. In addition, the BIPM will host on its website a table of conversion factors (see Section 4.6) and information on the practical realization of SI units (see Section 4.8).

7 COMMENTS ON THE NEW EDITION OF THE VIM

It was considered impractical to produce an agreed CCU position on the new edition of the *International Vocabulary of Basic and General Terms in Metrology* (VIM) within the limitations of this present meeting. Another meeting would be necessary to collect all comments from the CCU, but this would duplicate the work of the Joint Committee for Guides in Metrology (JCGM). Prof. Wallard stated that CCU members should respond through their local National Metrology Institutes and that the BIPM would compile the different comments.

8 MISCELLANEOUS

Prof. Himbert informed the meeting of the creation of a Working Group lead by Prof. Hubert Curien on “Base units and fundamental constants” at the Académie des Sciences of Paris. The terms of reference include drawing up recommendations to the French government on future organization of metrology in France, and also eventual re-definition of the SI base units in terms of fundamental constants. Collaboration between this Working Group and the CCU would naturally follow from the common participation of Dr Quinn, Dr Thomas, and himself.

9 DATE OF NEXT MEETING

The next meeting of the CCU will be held on 7-9 September 2005 (dates were agreed at the CIPM meeting in October 2004).

Prof. Mills thanked all participants for their patience and closed the meeting.

Dr J. Flowers, Rapporteur

October 2004

Appendix U 1.

Working documents submitted to the CCU at its 16th meeting

Working documents submitted to the CCU at its 16th meeting are on restricted access.