Conventions for writing the values of quantities in the SI

BY IAN MILLS*

Department of Chemistry, University of Reading, Reading RG6 6AD, UK

Possible improvements to the conventional rules for using and writing the values of quantities in the International System of Units (SI) are discussed in the light of recent suggestions for improving the system with a view to making it more adaptable to use in computer codes.

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The International System of Units, the SI (from the French Système Internationale d’Unités), is an internationally agreed system of units for the world, which is defined and maintained by the International Committee of Weights and Measures (Comité International des Poids et Mesures, CIPM), which operates out of the International Bureau of Weights and Measures (Bureau International des Poids et Mesures, BIPM) at Sèvres in France. The defining rules of the SI are published by the BIPM in the form of the SI Brochure, with the title The International System of Units, which is revised every 6 or 7 years as small changes in the SI are introduced. The current 8th edn. of the brochure was published in 2006 and is some 180 pages in both French and English, giving all details of the SI and its history (BIPM 2006a). At the same time, a four page Concise Summary of the SI was published (BIPM 2006b), which provides sufficient information on the SI for many every-day purposes. Chapter 5 of the brochure is concerned with the conventions adopted in the internationally accepted language of science for writing the values of quantities in the SI; it has the title Writing unit symbols and names and expressing the values of quantities. The final page of the concise summary contains the same information in an abbreviated form. Both the full brochure and the concise summary are freely available on the BIPM website at www.bipm.org/en/si/si_brochure, and hard copies may be purchased directly from the BIPM. These publications are referred to below as ‘the brochure’.

Users of the SI should read these references if they wish to ensure that they are using the conventions of scientific language in an internationally consistent manner.

*i.m.mills@reading.ac.uk

The accompanying reply can be viewed at http://dx.doi.org/doi:10.1098/rspa.2009.0138.
The standards produced by the International Organization for Standardization (ISO) are also a useful source of information, but they are primarily concerned with the names and symbols for quantities and the relationships between quantities (ISO 1993), whereas the BIPM publications are concerned with the SI units and with the language of science. The ISO standards are in the process of being revised at the time of writing. The revised standards will be known as ISO/IEC 80000, parts 1–14 (ISO/IEC 80000 2009), and the new editions will replace ISO 1000 and ISO 31 parts 1–13, as they appear. Other sources of information on symbols and conventions for quantities and units are the publications of some of the scientific unions. The International Union of Pure and Applied Chemistry (IUPAC) green book *Quantities, units and symbols in physical chemistry* published by the IUPAC (2007) is a particularly useful product for users throughout the physical sciences, although the title refers only to physical chemistry.

In a recent paper by Foster (2009), suggestions are made for improving the conventions for writing the values of quantities in the SI, with a view to making the system more attuned for computer use. I am writing this paper as President of the Consultative Committee for Units (CCU) at the BIPM in response to these suggestions, since the CCU is essentially responsible for drafting both the SI brochure and the concise summary of the SI. Foster’s suggestions are one example of many that are received at the BIPM, and are considered by the CCU. We welcome such suggestions, but they are not always followed for reasons similar to those discussed below. There are many conflicting factors to be considered in revising the conventions for using the SI, which call for caution in revising the rules. I am writing this short paper specifically in response to Foster’s suggestions, to explain some of the difficulties faced in revising the rules recommended in the brochure for the use of the SI.

Foster’s proposals are aimed at making the rules for using the SI more user-friendly for computer programming, so that programs such as MATHEMATICA can handle quantities and units automatically without user intervention. Thus, for example, if all SI unit names and symbols were indexed in a database, and if the rules of formatting were rigidly defined and followed, then since derived units of the SI can always be written as products of base units, a computer program should be able to recognize and simplify such products automatically. The CCU recognizes this as a desirable aim and, with collaboration from other groups, is working to improve the SI in this way. The subject is on our agenda. However, there are difficulties in achieving this aim.

One problem is that, although the use of SI units is becoming more widespread every year, nonetheless there are many non-SI units still in common use. Neither the CIPM nor any other authority has any control over the conventions adopted in using non-SI units. The user community invent and adopt non-SI units as they wish, and they are often used in ways that break the recommended rules for formatting SI units. This is particularly unsatisfactory when they are used in combination with SI units, as observed in chapter 5 of the brochure. However, it is pointless for any authority to attempt to ‘ban’ the use of non-SI units; such advice would be ignored and would only prove counter-productive. The use of non-SI units is a freedom that must always be available to users, both due to the importance of many historical published papers and books that pre-date the SI and use a wide variety of units, and also due to the need that is often argued for

the use of special non-SI units appropriate to particular specialized fields. Astronomy is one example of many: the SI units are not convenient for astronomers, and so they will probably continue to use the ‘astronomical unit’ and the ‘parsec’ as units of distance, although their relationship to the SI is obscure to those not working in astronomy. Nonetheless, it is important to emphasize the value of using the SI, both because the system sets a common standard among all fields of science and technology, for all the world community of science, and also because it generally simplifies the teaching of science to a new generation. Thus, users have to make their own decisions about the balance between the advantages of the SI, and the advantages that they perceive in the use of particular non-SI units that they may favour.

The CIPM, through the SI brochure, should—and does—make a strong case for using the SI, but it would be a mistake to set rigid rules that users are unlikely to follow. As examples where the same symbol is used with different meanings, the symbol \( t \) for the quantity time, \( T \) for temperature and \( T \) for the unit tesla, are distinguishable to a computer program only if the rules for the use of upper and lower case and for the use of italic are rigidly followed. Similar comments apply to the use of \( m \) for metre and the prefix \( m^- \) for milli \(( \times 10^{-3}) \), and the use of \( H \) for the unit henry and \( h^- \) for the prefix hecto \(( \times 10^2) \). The use of a space as a multiplier symbol is another example that poses problems: thus \( ms \) denotes a millisecond, but \( m \ s \) with a space denotes the product of a metre and a second. Foster suggests that a half-high dot should always be used between units to signify multiplication, so that, for example, the product of a metre and a second should always be written \( m \cdot s \). This is already a recommended notation, but in practice the half-high dot is rarely used as a multiplication symbol between units (or in other circumstances), presumably because it would prove tedious to follow such a rule on every occasion, and to require that this procedure should always be followed would probably be counter-productive. These examples illustrate the problems facing international committees that attempt to formulate rules for the use and formatting of such symbols.

Foster also raises problems associated with using the point on the line. This should not be used to indicate multiplication; it should be used only as a full stop, or as the decimal marker in formatting numbers with digits both before and after the decimal. The internationally agreed recommendation is that the decimal marker may be either a point or a comma on the line, according to custom in different languages and different countries. This leaves a problem when digits are grouped into threes for numbers with many digits, for easy reading. In many documents, it is a common practice to use a comma to group digits into threes when the point is used as the decimal marker, and vice versa. However, to avoid confusion, the recommendation for scientific use is to use only a thin space to group digits into threes for easy reading.

Another problem to be considered is that it is not helpful to be continually changing the rules, which has the appearance of ‘tinkering’ with the system. A good system of units and conventions should be stable and familiar to all users, and changes to the rules should be made only at wide intervals and for strong reasons. A suggestion that has been with the CCU for many years is that the multiple prefixes da-, h- and k- for deca-, hecto- and kilo- should be changed to capitals D-, H- and K-. This would make all the multiple prefixes capitals, and all the sub-multiple prefixes lower case, which would be a logical arrangement.
However, the symbol D is already used for the non-SI unit of electric dipole moment ‘debye’), and H and K are already used for the SI units henry and kelvin. This suggested change has been discussed, but has never been taken up by the CCU, mainly because it has been argued that it would be tinkering with the system for only marginal advantage. Yet another problem concerns the use of letters from the Greek alphabet for some of the SI units, such as $\Omega$ for the ohm and $\mu$- for the prefix micro, and the many Greek letters that are customarily used as symbols for quantities, such as $\mu$ for magnetic permeability, reduced mass, viscosity, Joule–Thomson coefficient, and for both electric and magnetic dipole moments. Greek letters still pose some problems for computer representations, but it would be difficult to persuade the community to abandon the use of all Greek letters.

Finally, Foster makes specific suggestions in his list (i)–(viii) on p. 2 of his paper, and in his further list under (i)–(iii) lower down the same page. I have already responded to his comments (i)–(vi) in the first list in the preceding paragraphs, and I believe no strong case for any change has been made. The CCU will nonetheless consider his comments. His comment (vii) that the symbol ‘cd’ could be taken to denote either a centiday or a candela is true, although the day is not an SI unit of time interval, and the combination of prefixes with non-SI units of time, such as the day, is expressly deprecated in the SI brochure. The symbol cd for candela begins with a lower case letter because we follow the convention that unit symbols begin with a capital letter only when they are named for an individual (such as newton, N; joule, J; hertz, Hz; etc.). Specialists in photometry and radiometry would also raise strong objections to any change in the symbol for a candela. Finally regarding Foster’s point (viii) that combining two prefixes to make a compound prefix leads to ambiguities, such combinations are expressly forbidden in the SI brochure.

Thus, although the CCU welcomes suggestions for changes such as those in Foster’s paper, I doubt whether any of his present suggestions are likely to find favour.

References

BIPM 2006a The international system of units, 8th edn. Sèvres, France: BIPM.
BIPM 2006b A concise summary of the SI. Sèvres, France: BIPM.