SCC 14 Conventions for Metrication of IEEE Standards
Approved October 31, 2017

These conventions are provided as guidelines for IEEE working groups and editors for the application of metric units as required by IEEE Policy 9.16[1] [B10]. They provide a high-level summary of the metric requirements from the Standards Coordinating Committee 14 (SCC14), which provides current information on quantities and units to all organizations preparing IEEE standards. SCC14 maintains, jointly with ASTM, the *American National Standard for Metric Practice*, IEEE/ASTM SI 10™ that provides the basis for the application of International System of Units (SI) in standards.

General Conventions & Best Practices

1. All measured and calculated values or quantities shall be expressed in SI units and units acceptable for use with the SI. By that is meant the units of the SI itself (e.g., IEEE/ASTM SI 10 Tables 1, 2, 3, and 4) plus the non-SI units "in use with the SI" (Table 6) and the accepted experimentally obtained units (Table 7).
2. Only standard unit and prefix spelled-out names and symbols are used. For best international Comprehension, symbols are preferred over spelled-out names.
3. A solely SI standard exclusively uses SI and accepted units. Non-accepted units shall not be used.

   Examples using accepted units: 20 °C 4 L/min 8 mm
4. A dual-unit technical standard may use both SI and non-SI units. SI units shall be provided in the primary position. Non-SI units may be provided in parentheses after SI units when required for clarity or informational purposes. Values stated in either SI or non-SI units are not interchangeable, they should be regarded separately, and used independently. Interchanging values from both unit systems may result in errors. The SI values are the authoritative values.

   The standard should inform the reader if non-SI units are obtained by mathematical conversion or by selecting a rational value. By 'rational value' is meant 'reasonable, rounded value'.

   Examples using rational values:

   22 °C (72 °F) 4 L (1 gal) 8 mm (0.30 in)

   Examples using conversion values:

   22 °C (71.6 °F) 4 L (1.1 gal, US) 8 mm (0.31 in)
5. Derived quantities formed from other quantities by division are written using the words "divided by" or "per" rather than the words "per unit" in order to avoid the appearance of associating a particular unit with the derived quantity.

   Example: Pressure is force divided by area, *but not*: Pressure is force per unit area
6. An object and any quantity describing the object are distinguished. (Note the difference between "surface" and "area," "body" and "mass," "resistor" and "resistance," "coil" and "inductance.")

   Example: The body accelerates at 5 m/s2 *but not*: The mass accelerates at 5 m/s2
7. It is highly preferable to give values of acceleration in meters per second squared, rather than relating them to the standard acceleration due to gravity.

   Example: 19.6 m/s^2 *but not*: 2g
8. Standardized quantity symbols such as those given in the ISO/IEC 80000 series [B13] are greatly preferred due to international acceptance. For example, R for resistance and Z_m for mechanical

---

[1] For more information on IEEE Policy, see http://www.ieee.org/about/corporate/governance/index.html .

impedance, and not words, acronyms, or ad hoc groups of letters shall be used. Similarly, standardized mathematical signs and symbols such as given in that same series shall be used, for example, "tan *x*" and not "tg *x*." More specifically, the base of "log" in equations is specified when required by writing $\log_a x$ (meaning *log* to the base *a* of *x*); or lb *x* (meaning $\log_2 x$), ln *x* (meaning $\log_e x$), or lg *x* (meaning $\log_{10} x$) may be used [B12].

9. A non-SI quantity may be a rational or substitution value (e.g., not mathematically equivalent) or obtained from mathematical conversion according to the methods of IEEE/ASTM SI 10 Annex A and Annex B.8.
10. Metrication of *normative* annexes is required, and metrication of *informative* annexes is highly preferred, but not required.
11. Two sets of numeric equations can be provided; however, the SI numeric equations should be listed first, followed by the non-SI numeric equations. Note that quantity equations do not involve units of measurement and thus are independent of all measurement systems.
12. Metrication questions on a standard or guide that cannot be resolved by editors shall be referred to SCC14 Review Subgroup (send e-mail to SCC14@ieee.org).

Exceptions to Use of Metric Units

1. The metric policy does not require metric products to be substituted for inch-based products [B1], [B4], and [B5]; however, it is recommended that all standards using non-metric fittings, wire sizes, material and valves provide alternative, equivalent metric devices.
2. A specific exception is given for trade sizes, such as AWG wire series and inch-based standards for fasteners. Such data need not be translated into metric terms. Documents using those should make the use of trade sizes clear when occurring. It is strongly preferred that mathematically equivalent metric values for those sizes be provided, either in place or in a table, for the sake of readers not familiar with those trade sizes.

   Examples of mathematical equivalent value:

   AWG 8 (diameter 3.26 mm, cross-sectional area 8.37 mm^2, 7 wire strand)

   1 in (25.4 mm diameter) bolt
3. Exceptions are permitted where a mechanical fit to an inch-based product is required, such as plugs and sockets.
4. Request for a specific exception: "IEEE Policy 9.16 recognizes the need for some exceptions and contains the following statement: Necessary exceptions to this policy, such as where conflicting industry practice exists, must be evaluated on an individual basis and approved by the responsible Major Board of the institute for specific period of time." In this case, a 'specific period of time' means, for example, life of the current revision, life of the standard, or a fixed period of time not to exceed 10 years.

   SCC14, as part of the coordination process, shall review requests for individual exceptions and shall report its recommendation to the IEEE-SA Standards Board. The IEEE-SA Standards board may accept or not accept the recommendation from SCC14.

Instructions for Document Review Checklist[2]

The following checklist is intended to help IEEE authors, working groups, and editors review the conformity of the standard with proper SI usage and the basic principles concerning quantities and units.

The checklist references found in square brackets indicate the clause(s) in which additional information may be found in *American National Standard for Metric Practice*, IEEE/ASTM SI 10-2016, which provides current information on quantities and units to all organizations developing IEEE standards.

The Document Review Checklist is provided separately on the following five pages, so that it can be utilized as a stand-alone document when required.

[2] Adapted from the checklist from the Guide for the Use of the International System of Units (SI), National Institute of Standards and Technology (NIST), NIST Special Publication 811, 2008 Edition.

Document Review Checklist			
SI Units			
(1)	☐	The SI provides symbols to represent units, such as m for meter [3.5.1.2]. Only SI units and those units recognized for use with the SI are used to express the values of quantities. Equivalent values in non-SI units are given in parentheses following values in acceptable units *only* when deemed necessary for the intended audience in a dual unit technical standard [3.3.1]. For example, 1 cm (0.39 in).	
(2)	☐	Unacceptability of attaching information to units: Unit symbols (or names) are not modified by the addition of subscripts or other information. Instead, modifiers shall be affixed to quantity symbols where needed. The following forms, for example, are used instead. [3.4.8.2 c)] V_{ac} = 1000 V *but not*: V = 1000 V_{ac} a mass fraction of 10 % *but not*: 10 % (*m*/*m*) or 10 % (by weight)	
Unit Names & Unit Symbol Usage			
(3)	☐	To avoid ambiguity, unit symbols are preferred over unit names [3.5.3.1 d)] .When two unit names are combined multiplicatively (to form a derived unit) separating the two unit names with a space is preferable but if not a hyphen shall be used, such as newton meter or newton-meter. Two derived units that may be written with neither a space nor hyphen are: watthour and voltampere. [3.5.3.1]	
(4)	☐	When two unit symbols are combined multiplicatively (to form a derived unit) separating the two unit symbols with a raised dot is preferable but if not a space shall be used. Exception: Two derived units have symbols that may be written with neither a raised dot nor a space: Wh and VA. [3.5.3.2]	
(5)	☐	Unacceptability of unit symbols and unit names together: Unit symbols and unit names are not mixed and mathematical operations are not applied to unit names. [3.5.3.1, 3.5.3.2, and 3.5.3.3]	
		Unit symbols with mathematical operator • kg/m^3 • kg · m^{-3} Unit name with "per" • kilogram per cubic meter	But not: Mixed unit name and unit symbol • kilogram/m^3 • kg/cubic meter Unit name with math operation • kilogram/cubic meter Unit symbol and textual "per" • kg per m^3 Unit name and math operation • kilogram per $meter^3$ • kilogram per m3
(6)	☐	Spell out units used in text without numerical values (e.g., “where the noise is given in decibels”). For units appearing with quantities, use standard symbols. Unit symbols are not to be used as shorthand or abbreviations for unit names in textual contexts.	

Document Review Checklist				
(7)	☐	Clarity in writing values of quantities. It is clear to which unit symbol a numerical value belongs and which mathematical operation applies to the value of a quantity because forms such as the following are used. [3.5.1.1 and 3.5.1.2]		
		35 cm × 48 cm	*but not*:	35 × 48 cm
		1 MHz to 10 MHz or (1 to 10) MHz	*but not:*	1 MHz – 10 MHz or 1 to 10 MHz
		20 ºC to 30 ºC or (20 to 30) ºC	*but not*:	20 ºC – 30 ºC or 20 to 30 ºC
		123 g ± 2 g or (123 ± 2) g	*but not:*	123 ± 2 g
		70 % ± 5 % or (70 ± 5) %	*but not*:	70 ± 5 %
		240 × (1 ± 10 %) V	*but not*:	240 V ± 10 % (one cannot add 240 V and 10 % since voltages and percentages have different units)
		4 mm, 6 mm, and 8 mm	*but not:*	4, 6, and 8 mm
Numerical Values and Symbols Format				
(8)	☐	The digits of numerical values having more than four digits on either side of the decimal marker should be separated into groups of three using a thin, fixed space (or condensed space) counting from both the left and right of the decimal marker. For example, 15 739.012 53 is highly preferred to 15739.01253. In the case of four digits, the space may be omitted unless needed to properly align digits in a table of values. If there are only four digits on each side of the decimal marker, treat them consistently. Commas are not used to separate digits into groups of three. [3.5.4.1] When decimal fractions are used, always add a leading zero before decimals, (e.g., 0.25). [3.2.1]		
(9)	☐	A fixed and non-breaking space between the numerical value and unit symbol, even when the value is used as an adjective, except in the case of superscript units for plane angle. Do not insert a hyphen, even when they are used as adjectives. [3.5.1.2 f) 3.5.1.2 e), and 3.5.2 d]		
		a 25 kg sphere	*but not*:	a 25-kg sphere
		an angle of 2º3'4"	*but not:*	an angle of 2 º3 '4 "
(10)	☐	Note that the raised circle is part of the unit symbol for degree Celsius, thus the space appears before the raised circle degree symbol and not between it and the uppercase C. (Symbols for non-SI temperature scales should be treated similarly in dual-unit standards) [3.5.1.2.e)]		
		20 ºC	*but not*:	20ºC or 20º C
(11)	☐	Note that the percent symbol is a unit symbol. A fixed and non-breaking space should appear between the percent symbol (%) and the preceding numerical value. Use the % symbol not the word percent. [3.4.8.2.c)]		
		70 %	*but not*:	70%
		3 %	*but not*:	3 percent
(12)	☐	Do not alter symbols to provide information with unit symbols (or names). For example, the form “the water content is 20 mL/kg” is used and not “20 mL H_2O/kg” or “20 mL of water/kg.” [3.5.1.3 e)]		

Document Review Checklist		
(13)	☐	Values of quantities are expressed in acceptable units using Arabic numerals and the symbols for the units to be as independent of language as possible. [3.5.1.2 e)] m = 5 kg *but not*: m = five kilograms or m = five kg the current was 15 A *but not*: the current was 15 amperes.
(14)	☐	The standard acceleration due to gravity g_n is a quantity and may be used with a coefficient: $2g_n$, with no space between the 2 and the g. But g_n is not a unit symbol and cannot be used as such, so 2 g_n is incorrect. 19.6 m/s^2 *but not* 2g_
Fonts, Types, and Symbols		
(15)	☐	Unit symbols are in roman type, and quantity symbols are in italic type with superscripts and subscripts in roman or italic type as appropriate. If the subscript represents a quantity, it is italicized; otherwise, it should be in roman type. [3.5.1.2 and 2.5.1.3]
Capitalization		
(16)	☐	When a unit name is derived from a proper name, then the unit symbol is capitalized. For example, pascal (Pa). All other unit names are to start in lowercase unless the name is used at the beginning of a sentence, which is rare. One exception is Celsius, but note that the unit is degree Celsius and degree starts with a lowercase letter [3.5.2 a)]. Use the capitalized letter L for liter to prevent confusion with the lowercase letter l with the number 1. For example, mL or L. [3.5.1.2]
Plurals		
(17)	☐	Unit symbols such as m, s, V, are not appended to indicate plurals. They are not to be followed by a period unless appearing at the end of a sentence. [3.5.1.2 c) and 3.5.1.2 d)] s *but not* ss cm *but not* cms kg *but not* kgs W *but not* Ws
(18)	☐	To form the plural of a unit formed by multiplication of other units, use the plural of the last unit in the product when spelling out unit names. For example: newton meters, not newtons meter or pascal seconds, not pascals second. When a quotient is involved, the last unit in the numerator is made plural. For example: kelvins per watt or kelvin meters per watt. [3.5.3.1 e)]
(19)	☐	Normal grammatical rules apply for the plurals of unit names. For example, henry (singular) or henries (plural). Exceptions: lux, hertz, and siemens (both singular and plural). [3.5.2]

Document Review Checklist		
Abbreviations & Prefixes		
(20)	☐	The combinations of letters "ppm," "ppb," and "ppt," and the terms part per million, part per billion, and part per trillion, and the like, shall not be used to express the values of quantities because they are language dependent terms. The following form, for example, is used instead: 2.0 µL/L. [3.4.8.2 d)]
(21)	☐	Do not use abbreviations such as sec (for either s or second), hr (for either h or hour) cc (for either cm^3 or cubic centimeter), or mps (for either m/s or meter per second). Only standard unit symbols, SI prefix symbols, unit names, and SI prefix names are to be used. [3.5.1.2 g)]
(22)	☐	Prefixes. Do not insert a space between a prefix and unit symbol. Do not place a space or a hyphen between the prefix and unit name. [3.5.1.2 f , 3.5.2 d] mg *but not:* m g milligram *but not:* milli gram milligram *but not:* milli-gram
Equations		
(23)	☐	Equations between quantities are used in preference to equations between numerical values. When a numerical-value equation is used, it is properly written and the corresponding quantity equation is given where possible. [3.5.5.2]
Tables & Graphs		
(24)	☐	It is highly preferable to use quantity calculus to label table headings and graph axes. Use quantity symbols instead of text, ensuring they are defined. For example: C/pF f/kHz a/(m/s^2) [3.5.5.2]
Mass and Weight		
(25)	☐	"The mass of a body is a measure of its inertial property or how much matter it contains. The weight of a body is a measure of the force exerted on it by gravity or the force needed to support it. Gravity on earth gives a body a downward acceleration of about 9.8 m/s^2."[3] When the word "weight" is used, the intended meaning sometimes is not clear. In science and technology, and thus technical standards, weight is a force for which the SI unit is the newton; in commerce and everyday use, weight is usually a synonym for mass, for which the SI unit is the kilogram. [Annex C.6]

[3] National Institute of Standards and Technology (NIST), Handbook 44, 2017, Appendix B – Units and Systems of Measurement, page B-10.

Amount-of-Substance, Concentration, and Molality		
(26)	☐	The obsolete term normality and the unit symbol N, and the obsolete term molarity and the unit symbol M, are not used, but the quantity amount-of-substance concentration of B (more commonly called concentration of B), and its symbol c_B and SI unit mol/m^3 (or a related acceptable unit), are used instead. Similarly, the obsolete term molal and the symbol m are not used, but the quantity molality of solute B, and its symbol b_B or m_B and SI unit mol/kg (or a related SI unit), are used instead. [3.5.3.4]

Resources for the Application of Metric Practice and the International System of Units (SI)

Metric practice

[B1] ASTM SI10-2016, IEEE/ASTM SI 10 American National Standard for Metric Practice

[B2] 945-1984™ - IEEE Recommended Practice for Preferred Metric Units for Use in Electrical and Electronics Science and Technology

[B3] 2014 IEEE-SA Standards Style Manual, see 12.3 Metric system

International System of Units (SI)

[B4] 270-2006™ - IEEE Standard Definitions for Selected Quantities, Units, and Related Terms, with Special Attention to the International System of Units (SI)

[B5] 260.1-2004™ - IEEE Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units)

[B6] 260.3-1993 (R2012) - American National Standard Mathematical Signs and Symbols for Use in Physical Sciences and Technology

[B7] ANSI/IEEE 260.4-1996 (R2004) - American National Standard Letter Symbols and Abbreviations for Quantities Used in Acoustics

[B8] 280-1985™ (R2003) - IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering,

[B9] 1541-2002™ (R2008) - IEEE Standard for Prefixes for Binary Multiples

General Resources

[B10] IEEE POLICIES 2017, The Institute of Electrical and Electronic Engineers, Inc., November 2016.

[B11] The International System of Units (SI), National Institute of Standards and Technology (NIST), NIST Special Publication 330, 2008 Edition

[B12] Guide for the Use of the International System of Units (SI), National Institute of Standards and Technology (NIST), NIST Special Publication 811, 2008 Edition

[B13] ISO/IEC 80000 series (Parts 1–14), *Quantities and Units*. Note that work continues on these in order to harmonize the parts in their internal references. This series is sometimes referred to as the *International System of Quantities*, but that is an informal name.