INTERNATIONAL STANDARD

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SI units and recommendations for the use of their multiples and of certain other units

Unités SI et recommandations pour l'emploi de leurs multiples et de certaines autres unités

Reference number
ISO 1000:1992(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1000 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors*.

This third edition cancels and replaces the second edition (ISO 1000:1981). The major technical changes from the second edition are the following:

— the decision by the International Committee for Weights and Measures (Comité International des Poids et Mesures, CIPM) in 1980 concerning the status of supplementary units has been incorporated;

— quantities and units from ISO 31, parts 9, 10, 12 and 13, have been added to annex A;

— the old definition of the metre in annex B has been replaced by the new definition.

The scope of Technical Committee ISO/TC 12 is standardization of units and symbols for quantities and units (and mathematical symbols) used within the different fields of science and technology, giving, where necessary, definitions of these quantities and units. Standard conversion factors for converting between the various units also come under the scope of the TC. In fulfilment of this responsibility, ISO/TC 12 has prepared ISO 31 and ISO 1000.

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Annex A forms an integral part of this International Standard. Annex B is for information only.

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SI units and recommendations for the use of their multiples and of certain other units

1 Scope

This International Standard

a) describes the International System of Units[1] (in clauses 3, 4 and 6);

b) recommends selected decimal multiples and sub-multiples of SI units for general use and gives certain other units which may be used with the International System of Units (in clauses 5 and 7, and annex A);

c) quotes the definitions of the SI base units (in annex B).

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 27-1:1971,[2] *Letter symbols to be used in electrical technology — Part 1: General*

3 SI units

The name International System of Units (Système International d'Unités), with the international abbreviation SI, was adopted by the 11th General Conference on Weights and Measures (Conférence Générale des Poids et Mesures, CGPM) in 1960.

This system includes:

— base units

— derived units including supplementary units

which together form the coherent system of SI units.

3.1 Base units

The International System of Units is based on the seven base units listed in table 1.

1) Full information about the International System of Units is given in a publication by the International Bureau of Weights and Measures (Bureau International des Poids et Mesures, BIPM): *Le Système International d'Unités* (*SI*), including an authorized English translation.

2) 5th edition, currently being revised.

Table 1 — SI base units

Base quantity	SI base unit	
	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

For the definitions of the base units, see annex B.

3.2 Derived units including supplementary units

Derived units are expressed algebraically in terms of base units. Their symbols are obtained by means of the mathematical signs of multiplication and division; for example, the SI unit for velocity is metre per second (m/s).

For some of the SI derived units, special names and symbols exist; those approved by the CGPM are listed in tables 2 and 3.

The SI units radian and steradian are called supplementary units. They are "dimensionless" derived units (more precisely, derived units of dimension one) with special names and symbols. Although the coherent unit for plane angle and for solid angle is expressed by the number 1, it is convenient to use the special names radian (rad) and steradian (sr) respectively instead of the number 1 in many practical cases; for example the SI unit for angular velocity can be written as radian per second (rad/s).

It may sometimes be useful to express derived units in terms of other derived units having special names; for example, the SI unit for electric dipole moment is usually expressed as C · m instead of A · s · m.

4 Multiples of SI units

The prefixes given in table 4 are used to form names and symbols of multiples (decimal multiples and sub-multiples) of the SI units.

The symbol of a prefix is considered to be combined with the kernel symbol[3] to which it is directly attached, forming with it a new symbol (for a decimal multiple or sub-multiple) which can be raised to a positive or negative power, and which can be combined with other unit symbols to form symbols for compound units.

EXAMPLES

$$1\ \text{cm}^3 = (10^{-2}\ \text{m})^3 = 10^{-6}\ \text{m}^3$$

$$1\ \mu\text{s}^{-1} = (10^{-6}\ \text{s})^{-1} = 10^{6}\ \text{s}^{-1}$$

$$1\ \text{mm}^2/\text{s} = (10^{-3}\ \text{m})^2/\text{s} = 10^{-6}\ \text{m}^2/\text{s}$$

Compound prefixes shall not be used; for example, write nm for nanometre, not mμm.

NOTE 1 For historical reasons the name of the base unit for mass, the kilogram, contains the name of the SI prefix "kilo". Names of the decimal multiples and sub-multiples of the unit of mass are formed by adding the prefixes to the word "gram", e.g. milligram (mg) instead of microkilogram (μkg).

3) In this case, the term "kernel symbol" means only a symbol for a base unit or a derived unit with a special name. See, however, note 1 in clause 4 about the base unit the kilogram.

Table 2 — SI derived units with special names, including SI supplementary units

Derived quantity	SI derived unit		
	Special name	Symbol	Expressed in terms of SI base units and SI derived units
plane angle	radian	rad	1 rad = 1 m/m = 1
solid angle	steradian	sr	1 sr = 1 m^2/m^2 = 1
frequency	hertz	Hz	1 Hz = 1 s^{-1}
force	newton	N	1 N = 1 kg · m/s^2
pressure, stress	pascal	Pa	1 Pa = 1 N/m^2
energy, work, quantity of heat	joule	J	1 J = 1 N · m
power, radiant flux	watt	W	1 W = 1 J/s
electric charge, quantity of electricity	coulomb	C	1 C = 1 A · s
electric potential, potential difference, tension, electromotive force	volt	V	1 V = 1 W/A
capacitance	farad	F	1 F = 1 C/V
electric resistance	ohm	Ω	1 Ω = 1 V/A
electric conductance	siemens	S	1 S = 1 $Ω^{-1}$
magnetic flux	weber	Wb	1 Wb = 1 V · s
magnetic flux density	tesla	T	1 T = 1 Wb/m^2
inductance	henry	H	1 H = 1 Wb/A
Celsius temperature	degree Celsius[1)]	°C	1 °C = 1 K
luminous flux	lumen	lm	1 lm = 1 cd · sr
illuminance	lux	lx	1 lx = 1 lm/m^2

1) Degree Celsius is a special name for the unit kelvin for use in stating values of Celsius temperature. (See also note 6 concerning the kelvin in annex B.)

Table 3 — SI derived units with special names admitted for reasons of safeguarding human health

Derived quantity	SI derived unit		
	Special name	Symbol	Expressed in terms of SI base units and SI derived units
activity (of a radionuclide)	becquerel	Bq	$1\ \mathrm{Bq} = 1\ \mathrm{s}^{-1}$
absorbed dose, specific energy imparted, kerma, absorbed dose index	gray	Gy	1 Gy = 1 J/kg
dose equivalent, dose equivalent index	sievert	Sv	1 Sv = 1 J/kg

Table 4 — SI prefixes

Factor	Prefix	
	Name	Symbol
10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

5 Use of SI units and their multiples

5.1 The choice of the appropriate multiple (decimal multiple or sub-multiple) of an SI unit is governed by convenience, the multiple chosen for a particular application being the one which will lead to numerical values within a practical range.

5.2 The multiple can usually be chosen so that the numerical values will be between 0,1 and 1 000. In the case of a compound unit containing a unit to the second or third power, this is not always possible.

EXAMPLES

$1{,}2 \times 10^{4}$ N	can be written as	12 kN
0,003 94 m	can be written as	3,94 mm
1 401 Pa	can be written as	1,401 kPa
$3{,}1 \times 10^{-8}$ s	can be written as	31 ns

However, in a table of values of the same quantity or in a discussion of such values within a given context, it will generally be better to use the same multiple for all items, even if some of the numerical values will then be outside the range 0,1 to 1 000. For certain quantities in particular applications, the same multiple is customarily used; for example, the millimetre is used for dimensions in most mechanical engineering drawings.

5.3 The number of prefixes used in forming compound units should be limited as far as is compatible with practical usage.

5.4 Errors in calculations can be avoided more easily if all quantities are expressed in SI units, powers of 10 being used instead of prefixes.

6 Rules for writing unit symbols

6.1 Unit symbols shall be printed in roman (upright) type (irrespective of the type used in the rest of the text), shall remain unaltered in the plural, shall be written without a final full stop (period) except for normal punctuation, e.g. at the end of a sentence, and shall be placed after the complete numerical value in the expression for a quantity, leaving a space between the numerical value and the unit symbol.

Unit symbols shall in general be written in lower case letters except that the first letter is written in upper case when the name of the unit is derived from a proper name.

EXAMPLES

m	metre
s	second
A	ampere
Wb	weber

6.2 When a compound unit is formed by multiplication of two or more units, this should be indicated in one of the following ways:

N · m, N m

NOTES

2 In systems with limited character sets a dot on the line is used instead of a half-high dot.

3 The latter form may also be written without a space, provided that special care is taken when the symbol for one of the units is the same as the symbol for a prefix, e.g. mN is used only for millinewton, not for metre newton.

When a compound unit is formed by dividing one unit by another, this should be indicated in one of the following ways:

$\frac{m}{s}$, m/s, $m \cdot s^{-1}$.

A solidus (/) shall not be followed by a multiplication sign or a division sign on the same line unless parentheses are inserted to avoid any ambiguity. In complicated cases negative powers or parentheses shall be used.

7 Non-SI units which may be used with SI units and their multiples

7.1 There are certain units, outside the SI, recognized by the CIPM as having to be retained because of their practical importance (see tables 5 and 6).

7.2 Prefixes given in table 4 may be attached to some of the units given in tables 5 and 6; for example, millilitre, ml. (See also annex A, column 6.)

7.3 In a limited number of cases, compound units are formed with the units given in tables 5 and 6 together with SI units and their multiples; for example, kg/h; km/h. (See also annex A, columns 5 and 6.)

NOTE 4 There are some other units outside the SI which are recognized by the CIPM for temporary use. They are given in column 7 of the table in annex A and marked by an asterisk (*).

Table 5 — Units used with the SI

Quantity	Unit		
	Name	**Symbol**	**Definition**
time	minute	min	1 min = 60 s
	hour	h	1 h = 60 min
	day	d	1 d = 24 h
plane angle	degree	°	1° = (π/180) rad
	minute	′	1′ = (1/60)°
	second	″	1″ = (1/60)′
volume	litre	l, L[1)]	$1\ l = 1\ dm^3$
mass	tonne[2)]	t	$1\ t = 10^3\ kg$

1) The two symbols for the litre are on an equal footing. The CIPM will, however, make a survey on the development of the use of the two symbols in order to see if one of the two may be suppressed.

2) Also called the metric ton in the English language.

Table 6 — Units used with the SI, whose values in SI units are obtained experimentally

Quantity	Unit		
	Name	Symbol	Definition
energy	electronvolt	eV	The electronvolt is the kinetic energy acquired by an electron in passing through a potential difference of 1 volt in vacuum: $1\ \text{eV} \approx 1{,}602\ 177 \times 10^{-19}\ \text{J}$.
mass	unified atomic mass unit	u	The unified atomic mass unit is equal to 1/12 of the mass of an atom of the nuclide ^{12}C: $1\ \text{u} \approx 1{,}660\ 540 \times 10^{-27}\ \text{kg}$.

Annex A
(normative)

Examples of decimal multiples and sub-multiples of SI units and of some other units which may be used

For a number of commonly used quantities, examples of decimal multiples and sub-multiples of SI units, as well as of some other units which may be used, are given in this annex. It is suggested that the selection shown, while not intended to be restrictive, will none the less prove helpful in presenting values of quantities in an identical manner in similar contexts within the various sectors of technology. For some needs (for example, in applications in science and education), it is recognized that greater freedom will be required in the choice of decimal multiples and sub-multiples of SI units than is exemplified in the list which follows.

Item No. in ISO 31: 1992	Quantity	SI unit	Selection of multiples and sub-multiples of the SI unit	Units outside the SI recognized by the CIPM as having to be retained, and for special cases some of their combinations with SI units		Remarks and information about units used in special fields
				Units	Multiples or sub-multiples of units given in column 5	
1	2	3	4	5	6	7
Part 1: Space and time						
1-1	angle, (plane angle)	rad (radian)	mrad µrad	° (degree) $1° = \frac{\pi}{180}$ rad ′ (minute) $1' = \frac{1°}{60}$ ″ (second) $1'' = \frac{1'}{60}$		gon [gon (or grade)], 1 gon = $\frac{\pi}{200}$ rad If the radian is not used, the units degree or gon (or grade) may be used. Decimal subdivisions of degree are preferable to minute and second for most applications. For the units degree, minute and second for plane angle, there shall be no space between the numerical value and the unit symbol.
1-2	solid angle	sr (steradian)				
1-3.1	length	m (metre)	km cm mm µm nm pm fm			1 nautical mile* = 1 852 m (exactly) * Recognized by the CIPM for temporary use.