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Quantities and units —

Part 0:
General principles

Grandeurs et unités —

Partie 0: Principes généraux

Reference number
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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 31-0 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors.*

This third edition cancels and replaces the second edition (ISO 31-0:1981). The major technical changes from the second edition are the following:

— new tables of SI base units, SI derived units, SI prefixes and some other recognized units have been added;

— a new subclause (2.3.3) on the unit "one" has been added;

— a new annex C on international organizations in the field of quantities and units has been added.

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.

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ISO 31 consists of the following parts, under the general title *Quantities and units*:

— *Part 0: General principles*

— *Part 1: Space and time*

— *Part 2: Periodic and related phenomena*

— *Part 3: Mechanics*

— *Part 4: Heat*

— *Part 5: Electricity and magnetism*

— *Part 6: Light and related electromagnetic radiations*

— *Part 7: Acoustics*

— *Part 8: Physical chemistry and molecular physics*

— *Part 9: Atomic and nuclear physics*

— *Part 10: Nuclear reactions and ionizing radiations*

— *Part 11: Mathematical signs and symbols for use in the physical sciences and technology*

— *Part 12: Characteristic numbers*

— *Part 13: Solid state physics*

Annexes A, B and C of this part of ISO 31 are for information only.

Quantities and units —

Part 0:
General principles

1 Scope

This part of ISO 31 gives general information about principles concerning physical quantities, equations, quantity and unit symbols, and coherent unit systems, especially the International System of Units, SI.

The principles laid down in this part of ISO 31 are intended for general use within the various fields of science and technology and as a general introduction to the other parts of ISO 31.

2 Quantities and units

2.1 Physical quantity, unit and numerical value

In ISO 31 only physical quantities used for the quantitative description of physical phenomena are treated. Conventional scales, such as the Beaufort scale, Richter scale and colour intensity scales, and quantities expressed as the results of conventional tests, e.g. corrosion resistance, are not treated here, neither are currencies nor information contents.

Physical quantities may be grouped together into categories of quantities which are mutually comparable. Lengths, diameters, distances, heights, wavelengths and so on would constitute such a category. Mutually comparable quantities are called "quantities of the same kind".

If a particular example of a quantity from such a category is chosen as a reference quantity called the *unit*, then any other quantity from this category can be expressed in terms of this unit, as a product of this unit and a number. This number is called the *numerical value* of the quantity expressed in this unit.

EXAMPLE

The wavelength of one of the sodium lines is

$\lambda = 5{,}896 \times 10^{-7}$ m

Here λ is the symbol for the physical quantity wavelength; m is the symbol for the unit of length, the metre; and $5{,}896 \times 10^{-7}$ is the numerical value of the wavelength expressed in metres.

In formal treatments of quantities and units, this relation may be expressed in the form

$$A = \{A\} \cdot [A]$$

where A is the symbol for the physical quantity, $[A]$ the symbol for the unit and $\{A\}$ symbolizes the numerical value of the quantity A expressed in the unit $[A]$. For vectors and tensors the components are quantities which may be expressed as described above.

If a quantity is expressed in another unit which is k times the first unit, then the new numerical value becomes $1/k$ times the first numerical value; the physical quantity, which is the product of the numerical value and the unit, is thus independent of the unit.

EXAMPLE

Changing the unit for the wavelength from the metre to the nanometre, which is 10^{-9} times the metre, leads to a numerical value which is 10^9 times the numerical value of the quantity expressed in metres.

Thus,

$\lambda = 5{,}896 \times 10^{-7}$ m $= 5{,}896 \times 10^{-7} \times 10^{9}$ nm $=$ 589,6 nm

REMARK ON NOTATION FOR NUMERICAL VALUES

It is essential to distinguish between the quantity itself and the numerical value of the quantity expressed in a particular unit. The numerical value of a quantity expressed in a particular unit could be indicated by placing braces (curly brackets) around the quantity symbol and using the unit as a subscript. It is, however, preferable to indicate the numerical value explicitly as the ratio of the quantity to the unit.

EXAMPLE

$\lambda/\mathrm{nm} = 589{,}6$

NOTE 1 This notation is particularly useful in graphs and in the headings of columns in tables.

2.2 Quantities and equations

2.2.1 Mathematical operations with quantities

Two or more physical quantities cannot be added or subtracted unless they belong to the same category of mutually comparable quantities.

Physical quantities are multiplied or divided by one another according to the rules of algebra; the product or the quotient of two quantities, A and B, satisfies the relations

$$AB = \{A\}\{B\} \cdot [A]\,[B]$$

$$\frac{A}{B} = \frac{\{A\}}{\{B\}} \cdot \frac{[A]}{[B]}$$

Thus, the product $\{A\}\{B\}$ is the numerical value $\{AB\}$ of the quantity AB, and the product $[A]\,[B]$ is the unit $[AB]$ of the quantity AB. Similarly, the quotient $\{A\}/\{B\}$ is the numerical value $\{A/B\}$ of the quantity A/B, and the quotient $[A]/[B]$ is the unit $[A/B]$ of the quantity A/B.

EXAMPLE

The speed v of a particle in uniform motion is given by

$v = l/t$

where l is the distance travelled in the time-interval t.

Thus, if the particle travels a distance $l = 6$ m in the time-interval $t = 2$ s, the speed v is equal to

$$v = \frac{l}{t} = \frac{6\ \mathrm{m}}{2\ \mathrm{s}} = 3\ \frac{\mathrm{m}}{\mathrm{s}}$$

The arguments of exponential, logarithmic and trigonometric functions, etc., are numbers, numerical values or combinations of dimension one of quantities (see 2.2.6).

EXAMPLES

$\exp(W/kT)$, $\ln(p/\mathrm{kPa})$, $\sin\alpha$, $\sin(\omega t)$

NOTE 2 The ratio of two quantities of the same kind and any function of that ratio, such as the logarithm of the ratio, are different quantities.

2.2.2 Equations between quantities and equations between numerical values

Two types of equation are used in science and technology: *equations between quantities*, in which a letter symbol denotes the physical quantity (i.e. numerical value × unit), and *equations between numerical values*. Equations between numerical values depend on the choice of units, whereas equations between quantities have the advantage of being independent of this choice. Therefore the use of equations between quantities should normally be preferred.

EXAMPLE

A simple equation between quantities is

$v = l/t$

as given in 2.2.1.

Using, for example, kilometres per hour, metres and seconds as the units for velocity, length and time, respectively, we may derive the following equation between numerical values:

$\{v\}_{\mathrm{km/h}} = 3{,}6\{l\}_{\mathrm{m}}/\{t\}_{\mathrm{s}}$

The number 3,6 which occurs in this equation results from the particular units chosen; with other choices it would generally be different.

If in this equation the subscripts indicating the unit symbols are omitted, one obtains

$\{v\} = 3{,}6\{l\}/\{t\}$

an equation between numerical values which is no longer independent of the choice of units and is therefore not recommended for use. If, nevertheless, equations between numerical values are used, the units shall be clearly stated in the same context.

2.2.3 Empirical constants

An empirical relation is often expressed in the form of an equation between the numerical values of certain physical quantities. Such a relation depends on the units in which the various physical quantities are expressed.

An empirical relation between numerical values can be transformed into an equation between physical quantities, containing one or more empirical constants. Such an equation between physical quantities has the advantage that the form of the equation is independent of the choice of the units. The numerical values of the empirical constants occurring in such an equation depend, however, on the units in which they are expressed, as is the case with other physical quantities.

EXAMPLE

The results of measuring the length l and the periodic time T at a certain station, for each of several pendulums, can be represented by one quantity equation

$$T = C \cdot l^{1/2}$$

where the empirical constant C is found to be

$$C = 2{,}006\ \mathrm{s/m^{1/2}}$$

(Theory shows that $C = 2\pi g^{-1/2}$, where g is the local acceleration of free fall.)

2.2.4 Numerical factors in quantity equations

Equations between quantities sometimes contain *numerical factors*. These numerical factors depend on the definitions chosen for the quantities occurring in the equations.

EXAMPLES

1 The kinetic energy E_k of a particle of mass m and speed v is

$$E_k = \frac{1}{2} m v^2$$

2 The capacitance C of a sphere of radius r in a medium of permittivity ε is

$$C = 4\pi\varepsilon r$$

2.2.5 Systems of quantities and equations between quantities; base quantities and derived quantities

Physical quantities are related to one another through equations that express laws of nature or define new quantities.

For the purpose of defining unit systems and introducing the concept of dimensions, it is convenient to consider some quantities as mutually independent, i.e. to regard these as *base quantities*, in terms of which the other quantities can be defined or expressed by means of equations; the latter quantities are called *derived quantities*.

It is a matter of choice how many and which quantities are considered to be base quantities.

The whole set of physical quantities included in ISO 31 is considered as being founded on seven base quantities: length, mass, time, electric current, thermodynamic temperature, amount of substance and luminous intensity.

In the field of mechanics a system of quantities and equations founded on three base quantities is generally used. In ISO 31-3, the base quantities used are length, mass and time.

In the field of electricity and magnetism a system of quantities and equations founded on four base quantities is generally used. In ISO 31-5, the base quantities used are length, mass, time and electric current.

In the same field, however, systems founded on only three base quantities, length, mass and time, in particular the "Gaussian" or symmetric system, have been widely used. (See ISO 31-5:1992, annex A.)

2.2.6 Dimension of a quantity

Any quantity Q can be expressed in terms of other quantities by means of an equation. The expression may consist of a sum of terms. Each of these terms can be expressed as a product of powers of base quantities $A, B, C, \ldots$ from a chosen set, sometimes multiplied by a numerical factor ξ, i.e. $\xi A^\alpha B^\beta C^\gamma \ldots$, where the set of exponents $(\alpha, \beta, \gamma, \ldots)$ is the same for each term.

The *dimension* of the quantity Q is then expressed by the dimensional product

$$\dim Q = \mathrm{A}^\alpha \mathrm{B}^\beta \mathrm{C}^\gamma \ldots$$

where A, B, C, ... denote the dimensions of the base quantities $A, B, C, \ldots$, and where $\alpha, \beta, \gamma, \ldots$ are called the *dimensional exponents*.

A quantity all of whose dimensional exponents are equal to zero is often called a *dimensionless* quantity. Its dimensional product or dimension is $A^0 B^0 C^0 ... = 1$. Such a quantity *of dimension one* is expressed as a number.

EXAMPLE

If the dimensions of the three base quantities length, mass and time are denoted by L, M and T respectively, the dimension of the quantity work is expressed by dim $W = L^2MT^{-2}$, and the dimensional exponents are 2, 1 and −2.

In the system founded on the seven base quantities length, mass, time, electric current, thermodynamic temperature, amount of substance and luminous intensity, the base dimensions may be denoted by L, M, T, I, Θ, N and J respectively and the dimension of a quantity Q becomes in general

$$\dim Q = L^{\alpha}M^{\beta}T^{\gamma}I^{\delta}\Theta^{\varepsilon}N^{\zeta}J^{\eta}$$

EXAMPLES

Quantity	Dimension
velocity	LT^{-1}
angular velocity	T^{-1}
force	LMT^{-2}
energy	L^2MT^{-2}
entropy	$L^2MT^{-2}\Theta^{-1}$
electric potential	$L^2MT^{-3}I^{-1}$
permittivity	$L^{-3}M^{-1}T^4I^2$
magnetic flux	$L^2MT^{-2}I^{-1}$
illuminance	$L^{-2}J$
molar entropy	$L^2MT^{-2}\Theta^{-1}N^{-1}$
Faraday constant	TIN^{-1}
relative density	1

In ISO 31, the dimensions of the quantities are not explicitly stated.

2.3 Units

2.3.1 Coherent unit systems

Units might be chosen arbitrarily, but making an independent choice of a unit for each quantity would lead to the appearance of additional numerical factors in the equations between the numerical values.

It is possible, however, and in practice more convenient, to choose a system of units in such a way that the equations between numerical values have exactly the same form (including the numerical factors) as the corresponding equations between the quantities. A unit system defined in this way is called *coherent* with respect to the system of quantities and equations in question. The SI is such a system. The corresponding system of quantities is given in ISO 31-1 to ISO 31-10 and in ISO 31-12 and ISO 31-13.

For a particular system of quantities and equations, a coherent system of units is obtained by first defining units for the base quantities, the *base units*. Then for each derived quantity, the definition of the corresponding *derived unit* in terms of the base units is given by an algebraic expression obtained from the dimensional product (see 2.2.6) by replacing the symbols for the base dimensions by those of the base units. In particular, a quantity of dimension one acquires the unit 1. In such a coherent unit system no numerical factor other than the number 1 ever occurs in the expressions for the derived units in terms of the base units.

EXAMPLES

Quantity	Equation	Dimension	Symbol for derived unit
speed	$v = \frac{dl}{dt}$	LT^{-1}	m/s
force	$F = m\frac{d^2l}{dt^2}$	MLT^{-2}	$kg \cdot m/s^2$
kinetic energy	$E_k = \frac{1}{2}mv^2$	ML^2T^{-2}	$kg \cdot m^2/s^2$
potential energy	$E_p = mgh$	ML^2T^{-2}	$kg \cdot m^2/s^2$
energy	$E = \frac{1}{2}mv^2 + mgh$	ML^2T^{-2}	$kg \cdot m^2/s^2$
relative density	$d = \frac{\varrho}{\varrho_0}$	1	1

2.3.2 SI units and their decimal multiples and sub-multiples

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*.

2.3.2.1 Base units

The seven base units are listed in table 1.

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

2.3.2.2 Derived units including supplementary units

The expressions for the coherent derived units in terms of the base units can be obtained from the dimensional products by using the following formal substitutions:

$L \rightarrow m$	$I \rightarrow A$
$M \rightarrow kg$	$\Theta \rightarrow K$
$T \rightarrow s$	$N \rightarrow mol$
	$J \rightarrow cd$

In 1960, the CGPM classified the SI units radian, rad, and steradian, sr, for plane angle and solid angle respectively as "supplementary units".

In 1980, the *International Committee for Weights and Measures* (Comité International des Poids et Mesures, CIPM) decided to interpret the class of supplementary units in the SI as a class of dimensionless derived units for which the CGPM allows the freedom of using or not using them in expressions for SI derived units.

Although, as a consequence of this interpretation, the coherent unit for plane angle and for solid angle is the number 1, it is convenient to use the special names radian, rad, and steradian, sr, instead of the number 1 in many practical cases.

EXAMPLES

Quantity	Symbol for SI unit expressed in terms of the seven base units (and the supplementary units in some cases)
velocity	m/s
angular velocity	rad/s or s^{-1}
force	$kg \cdot m/s^2$
energy	$kg \cdot m^2/s^2$
entropy	$kg \cdot m^2/(s^2 \cdot K)$
electric potential	$kg \cdot m^2/(s^3 \cdot A)$
permittivity	$A^2 \cdot s^4/(kg \cdot m^3)$
magnetic flux	$kg \cdot m^2/(s^2 \cdot A)$
illuminance	$cd \cdot sr/m^2$
molar entropy	$kg \cdot m^2/(s^2 \cdot K \cdot mol)$
Faraday constant	$A \cdot s/mol$
relative density	1

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

It is often of advantage to use special names and symbols in compound expressions for units.

EXAMPLES

1 Using the derived unit joule $(1\ J = 1\ m^2 \cdot kg \cdot s^{-2})$, one may write

Quantity	Symbol for SI unit
molar entropy	$J \cdot K^{-1} \cdot mol^{-1}$

2 Using the derived unit volt $(1\ V = 1\ m^2 \cdot kg \cdot s^{-3} \cdot A^{-1})$, one may write

Quantity	Symbol for SI unit
permittivity	$s \cdot A \cdot m^{-1} \cdot V^{-1}$

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 ISO 31-4:1992, items 4-1.a and 4-2.a.)

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 Bq = 1 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

2.3.2.3 SI prefixes

In order to avoid large or small numerical values, decimal multiples and sub-multiples of the SI units are added to the coherent system within the framework of the SI. They are formed by means of the prefixes listed in table 4.

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

For information about the use of the prefixes, see 3.2.4.

The SI units and their decimal multiples and sub-multiples formed by use of the prefixes are specially recommended.

2.3.3 The unit one

The coherent SI unit for any quantity of dimension one is the unit one, symbol 1. It is generally not written out explicitly when such a quantity is expressed numerically.

EXAMPLE

Refractive index $n = 1{,}53 \times 1 = 1{,}53$

In the case of certain such quantities, however, the unit 1 has special names that could be used or not, depending on the context.

EXAMPLES

Plane angle	$\alpha = 0{,}5$ rad = 0,5
Solid angle	$\Omega = 2{,}3$ sr = 2,3
Level of a field quantity	$L_F = 12$ Np = 12

Decimal multiples and sub-multiples of the unit one are expressed by powers of 10. They shall not be expressed by combining the symbol 1 with a prefix.

In some cases the symbol % (per cent) is used for the number 0,01.

EXAMPLE

Reflection factor $r = 0{,}8 = 80$ %

NOTES

3 In some countries the symbol ‰ ("per mill", or per thousand) is used for the number 0,001. This symbol should be avoided.

4 Since per cent and per mill are numbers it is in principle meaningless to speak about percentage by mass or percentage by volume. Additional information, such as % *(m/m)* or % *(V/V)*, should not therefore be attached to the unit symbol. The preferred way of expressing a mass fraction is: "the mass fraction is 0,67" or "the mass fraction is 67 %", and the preferred way of expressing a volume fraction is: "the volume fraction is 0,75" or "the volume fraction is 75 %". Mass and volume fractions can also be expressed in the form 5 μg/g or 4,2 ml/m^3.

Abbreviations such as ppm, pphm and ppb shall not be used.

2.3.4 Other unit systems and miscellaneous units

The CGS system of mechanical units is a coherent system the base units of which are centimetre, gram and second for the three base quantities length, mass and time.

In practice this system was enlarged by adding the kelvin, the candela and the mole as base units for the base quantities thermodynamic temperature, luminous intensity and amount of substance.

Units used in electricity and magnetism have been defined in the CGS system in several ways depending on the system of quantities and equations chosen. The "Gaussian" or symmetric CGS system, coherent with the "Gaussian" or symmetric system of quantities and equations founded on three base quantities, has been widely used. For further information on this system, see ISO 31-5:1992, annex A.

The special names and symbols for derived CGS units such as dyne, erg, poise, stokes, gauss, oersted and maxwell *shall not be used together with the SI.*

In other parts of ISO 31, the special names for the derived CGS units are given in informative annexes which are not integral parts of the standards.

There are certain units outside the SI which are recognized by the CIPM as having to be retained for use together with the SI, e.g. minute, hour and electronvolt. These units are given in tables 5 and 6.

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 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 eV ≈ 1,602 177 × 10^{-19} 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 u ≈ 1,660 540 × 10^{-27} kg.

Other coherent systems of units have been defined, e.g. a system based on the units foot, pound and second and a system based on the units metre, kilogram-force and second.

Apart from these, other units have been defined which do not belong to any coherent system, e.g. the atmosphere, the nautical mile and the curie.

3 Recommendations for printing symbols and numbers

3.1 Symbols for quantities

3.1.1 Symbols

The symbols for quantities are generally single letters of the Latin or Greek alphabet, sometimes with subscripts or other modifying signs. These symbols are printed in italic (sloping) type (irrespective of the type used in the rest of the text).

The symbol is not followed by a full stop except for normal punctuation, e.g. at the end of a sentence.

NOTES

5 Symbols for quantities are given in ISO 31-1 to ISO 31-10 and in ISO 31-12 and ISO 31-13.

6 Notations for vectorial and other non-scalar quantities are given in ISO 31-11, on mathematical signs and symbols.

7 Exceptionally, symbols made up of two letters are sometimes used for combinations of dimension one of quantities (e.g. Reynolds number, *Re*). If such a two-letter symbol appears as a factor in a product, it is recommended that it be separated from the other symbols.

3.1.2 Rules for the printing of subscripts

When, in a given context, different quantities have the same letter symbol or when, for one quantity, different applications or different values are of interest, a distinction can be made by use of subscripts.

The following principles for the printing of subscripts are recommended.

A subscript that represents a symbol for a physical quantity is printed in italic (sloping) type.

Other subscripts are printed in roman (upright) type.

EXAMPLES

Upright subscripts		Sloping subscripts	
C_g	(g: gas)	C_p	(*p*: pressure)
g_n	(n: normal)	$\Sigma_n a_n \vartheta_n$	(*n*: running number)
μ_r	(r: relative)	$\Sigma_x a_x b_x$	(*x*: running number)
E_k	(k: kinetic)	g_{ik}	(*i*, *k*: running numbers)
χ_e	(e: electric)	p_x	(*x*: *x*-coordinate)
$T_{1/2}$	(1/2: half)	I_λ	(λ: wavelength)

NOTES

8 Numbers as subscripts should be printed in roman (upright) type. However, letter symbols representing numbers are generally printed in italic (sloping) type.

9 For use of subscripts, see also special remarks to ISO 31-6 and ISO 31-10.

3.1.3 Combination of symbols for quantities; elementary operations with quantities

When symbols for quantities are combined in a product, this process of combination may be indicated in one of the following ways:

ab, $a\ b$, $a \cdot b$, $a \times b$

NOTES

10 In some fields, e.g. in vector analysis, distinction is made between $\boldsymbol{a} \cdot \boldsymbol{b}$ and $\boldsymbol{a} \times \boldsymbol{b}$.

11 For multiplication of numbers, see 3.3.3.

12 In systems with limited character sets a dot on the line may be used instead of a half-high dot.

Division of one quantity by another may be indicated in one of the following ways:

$\frac{a}{b}$, a/b or by writing the product of a and b^{-1},

e.g. $a \cdot b^{-1}$

The procedure can be extended to cases where the numerator or the denominator, or both, are themselves products or quotients, but in such a combination a solidus (/) should not be followed by a multiplication sign or a division sign on the same line unless parentheses are inserted to avoid any ambiguity.

EXAMPLES

$\frac{ab}{c} = ab/c = abc^{-1}$

$\frac{a/b}{c} = (a/b)/c = ab^{-1}c^{-1}$, but not $a/b/c$;

however, $\frac{a/b}{c/d} = \frac{ad}{bc}$

$\frac{a}{bc} = a/(b \cdot c) = a/bc$, but not $a/b \cdot c$

The solidus can be used in cases where the numerator and the denominator involve addition or subtraction, provided parentheses (or brackets or braces) are employed.

EXAMPLES

$(a + b)/(c + d)$ means $\frac{a+b}{c+d}$;
the parentheses are required.

$a + b/c + d$ means $a + \frac{b}{c} + d$;
misunderstanding may, however, be avoided by writing it as $a + (b/c) + d$

Parentheses should also be used to remove ambiguities which may arise from the use of certain other signs and symbols for mathematical operations.

3.2 Names and symbols for units

3.2.1 International symbols for units

When international symbols for units exist, they, and no other, shall be used.[1] They 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.

Any attachment to a unit symbol as a means of giving information about the special nature of the quantity or context of measurement under consideration is incorrect.

EXAMPLE

$U_{max} = 500$ V (not $U = 500$ V_{max})

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

EXAMPLES

m	metre
s	second
A	ampere
Wb	weber

3.2.2 Combination of symbols for units

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

13 In systems with limited character sets a dot on the line may be used instead of a half-high dot.

14 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.

EXAMPLE

mN means millinewton, not metre newton.

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

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

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.

3.2.3 Printing of symbols for units

No recommendation is made or implied about the font of upright type in which symbols for units are to be printed.

NOTE 15 In this series of publications the font used in such cases is generally that of the associated text, but this does not constitute a recommendation.

3.2.4 Printing and use of prefixes

Symbols for prefixes should be printed in roman (upright) type without a space between the symbol for the prefix and the symbol for the unit.

1) For the representation of units in applications with limited character sets, the user is referred to ISO 2955:1983, *Information processing — Representation of SI and other units in systems with limited character sets.*

Compound prefixes shall not be used.

EXAMPLE

Write nm (nanometre) for 10^{-9} m, not mμm.

The symbol of a prefix is considered to be combined with the single unit symbol 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 (see 3.2.2).

EXAMPLES

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

$$1\ \mu\mathrm{s}^{-1} = \left(10^{-6}\ \mathrm{s}\right)^{-1} = 10^{6}\ \mathrm{s}^{-1}$$

$$1\ \mathrm{kA/m} = \left(10^{3}\ \mathrm{A}\right)/\mathrm{m} = 10^{3}\ \mathrm{A/m}$$

NOTE 16 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).

3.2.5 Spelling of names of units in the English language

Where there are differences in the spelling of names of units within the English language, the spelling as given in the Oxford English Dictionary (Oxford: Clarendon Press) is used in the English-language versions of ISO 31-0 to ISO 31-13. This does not imply a preference over the spellings used in other English-speaking countries.

3.3 Numbers

3.3.1 Printing of numbers

Numbers should generally be printed in roman (upright) type.

To facilitate the reading of numbers with many digits, these may be separated into suitable groups, preferably of three, counting from the decimal sign towards the left and the right; the groups should be separated by a small space, and never by a comma or a point, nor by any other means.

3.3.2 Decimal sign

The decimal sign is a comma on the line.

If the magnitude of the number is less than unity, the decimal sign should be preceded by a zero.

NOTE 17 In documents in the English language, a dot is often used instead of a comma. If a dot is used, it should be on the line. In accordance with an ISO Council decision, the decimal sign is a comma in ISO documents.

3.3.3 Multiplication of numbers

The sign for multiplication of numbers is a cross (×) or a dot half-high (·).

NOTES

18 If a dot half-high is used as the multiplication sign, a comma should be used as the decimal sign. If a dot is used as the decimal sign, a cross should be used as the multiplication sign.

19 In ISO documents, the dot is not used directly between numbers to indicate multiplication.

3.4 Expressions for quantities

The symbol of the unit shall be placed after the numerical value in the expression for a quantity, leaving a space between the numerical value and the unit symbol. It should be noted that, in accordance with this rule, the symbol °C for degree Celsius shall be preceded by a space when expressing a Celsius temperature.

The only exceptions to this rule are for the units degree, minute and second for plane angle, in which case there shall be no space between the numerical value and the unit symbol.

If the quantity to be expressed is a sum or a difference of quantities then either parentheses shall be used to combine the numerical values, placing the common unit symbol after the complete numerical value, or the expression shall be written as the sum or difference of expressions for the quantities.

EXAMPLES

$$l = 12\ \mathrm{m} - 7\ \mathrm{m} = (12 - 7)\ \mathrm{m} = 5\ \mathrm{m}$$

$$t = 28{,}4\ ^\circ\mathrm{C} \pm 0{,}2\ ^\circ\mathrm{C} = (28{,}4 \pm 0{,}2)\ ^\circ\mathrm{C}$$

(not $28{,}4 \pm 0{,}2\ ^\circ\mathrm{C}$)

$$\lambda = 220 \times (1 \pm 0{,}02)\ \mathrm{W/(m \cdot K)}$$

3.5 Symbols for chemical elements and nuclides

Symbols for chemical elements shall be written in roman (upright) type (irrespective of the type used in the rest of the text). The symbol is not followed by a full stop except for normal punctuation, e.g. at the end of a sentence.

EXAMPLES

H He C Ca

A complete list of the symbols for the chemical elements is given in ISO 31-8:1992, annex A, and ISO 31-9:1992, annex A.

The attached subscripts or superscripts specifying a nuclide or molecule shall have the following meanings and positions.

The nucleon number (mass number) of a nuclide is shown in the left superscript position, e.g.

^{14}N

The number of atoms of a nuclide in a molecule is shown in the right subscript position, e.g.

$^{14}N_2$

The proton number (atomic number) may be indicated in the left subscript position, e.g.

$_{64}Gd$

If necessary, a state of ionization or an excited state may be indicated in the right superscript position.

EXAMPLES

State of ionization:	Na^+
	PO_4^{3-} or $(PO_4)^{3-}$
Electronic excited state:	$He^{\bullet}$, $NO^{\bullet}$
Nuclear excited state:	$^{110}Ag^{*}$, $^{110}Ag^{m}$

3.6 Mathematical signs and symbols

Mathematical signs and symbols recommended for use in the physical sciences and technology are given in ISO 31-11.

3.7 Greek alphabet (upright and sloping types)

alpha	Α	α	*Α*	*α*
beta	Β	β	*Β*	*β*
gamma	Γ	γ	*Γ*	*γ*
delta	Δ	δ	*Δ*	*δ*
epsilon	Ε	ε, ϵ	*Ε*	*ε, ϵ*
zeta	Ζ	ζ	*Ζ*	*ζ*
eta	Η	η	*Η*	*η*
theta	Θ	ϑ, θ	*Θ*	*ϑ, θ*
iota	Ι	ι	*Ι*	*ι*
kappa	Κ	ϰ, κ	*Κ*	*ϰ, κ*
lambda	Λ	λ	*Λ*	*λ*
mu	Μ	μ	*Μ*	*μ*
nu	Ν	ν	*Ν*	*ν*
xi	Ξ	ξ	*Ξ*	*ξ*
omicron	Ο	ο	*Ο*	*ο*
pi	Π	π, ϖ	*Π*	*π, ϖ*
rho	Ρ	ϱ, ρ	*Ρ*	*ϱ, ρ*
sigma	Σ	σ	*Σ*	*σ*
tau	Τ	τ	*Τ*	*τ*
upsilon	Υ	υ	*Υ*	*υ*
phi	Φ	φ, ϕ	*Φ*	*φ, ϕ*
chi	Χ	χ	*Χ*	*χ*
psi	Ψ	ψ	*Ψ*	*ψ*
omega	Ω	ω	*Ω*	*ω*

Way of placing the lower case letters of the Greek alphabet relative to the baseline in print.

α_β_γ_δ_ε_ϵ_ζ_η_ϑ_θ_ι_ϰ_κ_λ_μ_ν_ξ_ο_π_ϖ_ϱ_ρ_σ_
τ_υ_φ_ϕ_χ_ψ_ω_

Annex A
(informative)

Guide to terms used in names for physical quantities

A.1 General

If no specific name for a physical quantity exists, a name is commonly formed in combination with terms like coefficient, factor, parameter, ratio, constant, etc. Similarly, terms like specific, density, molar, etc., are added to names of physical quantities to indicate other related or derived quantities. Just as in the choice of an appropriate symbol, the naming of a physical quantity may also need some guidance.

It is not the intention of this guide to impose strict rules or to eliminate the relatively frequent deviations which have been incorporated in the various scientific languages.

It seems useful, however, to have some guidelines for the usage of these terms. It is possible in this way to give, by the name chosen for a particular quantity, more information about the nature of that quantity. It is hoped that these guidelines will be followed when new names of quantities are introduced, and that, in forming new terms and in reviewing old ones, deviations from these guidelines will be critically examined.

NOTE 20 Most of the examples in this annex are drawn from existing practice and are not intended to constitute recommendations.

A.2 Coefficients, factors

If, under certain conditions, a quantity A is proportional to a quantity B, this can be expressed by the multiplicative relation $A = k \cdot B$. The quantity k which occurs as a multiplier in this equation is often called a coefficient or a factor.

A.2.1 The term *coefficient* should be used when the two quantities A and B have different dimensions.

EXAMPLES

Hall coefficient: A_H	$\boldsymbol{E}_H = A_H(\boldsymbol{B} \times \boldsymbol{J})$
linear expansion coefficient: α_l	$dl/l = \alpha_l \, dT$
diffusion coefficient: D	$\boldsymbol{J} = -D \, \mathbf{grad} \, n$

NOTE 21 Sometimes the term *modulus* is used instead of the term coefficient.

EXAMPLE

modulus of elasticity: E	$\sigma = E\varepsilon$

A.2.2 The term *factor* should be used when the two quantities have the same dimension. A factor is therefore a multiplier of dimension one.

EXAMPLES

coupling factor: k	$L_{mn} = k\sqrt{L_m L_n}$
quality factor: Q	$\lvert X \rvert = QR$
friction factor: μ	$F = \mu F_n$

A.3 Parameters, numbers, ratios

A.3.1 Combinations of physical quantities which occur as such in equations are often considered to constitute new quantities. Such quantities are sometimes called *parameters.*

EXAMPLE

Grüneisen parameter: γ $\gamma = \alpha_V / \varkappa c_V \varrho$

A.3.2 Some combinations of dimension one of physical quantities, such as those occurring in the description of transport phenomena, are called *characteristic numbers* and carry the word *number* in their names.

EXAMPLES

Reynolds number: Re $Re = \varrho v l / \eta$

Prandtl number: Pr $Pr = \eta c_p / \lambda$

A.3.3 Quotients of dimension one of two quantities are often called *ratios.*

EXAMPLES

heat capacity ratio: γ $\gamma = C_p / C_V$

thermal diffusion ratio: k_T $k_T = D_T / D$

mobility ratio: b $b = \mu_- / \mu_+$

NOTES

22 Sometimes the term *fraction* is used for ratios smaller than one.

EXAMPLES

mass fraction: w_B $w_B = m_B / \Sigma_A m_A$

packing fraction: f $f = \Delta_r / A$

23 The term *index* is sometimes used instead of ratio. Extension of this usage is not recommended.

EXAMPLE

refractive index: n $n = c_0 / c$

A.4 Levels

The logarithm of the ratio of a quantity, F, and a reference value of that quantity, F_0, is called a *level.*

EXAMPLE

level of a field quantity: L_F $L_F = \ln(F/F_0)$

A.5 Constants

A.5.1 A physical quantity which has the same value under all circumstances is called a *universal constant.* Unless a special name exists, its name explicitly includes the term "constant".

EXAMPLES

gravitational constant: G

Planck constant: h

A.5.2 A physical quantity which has for a particular substance the same value under all circumstances, is called a *constant of matter.* Again — provided no special name exists — the name of such a quantity includes the term "constant".

EXAMPLE

decay constant for a particular nuclide: λ

A.5.3 Other physical quantities which keep the same value only under particular circumstances, or which result from mathematical calculations, are also sometimes given names including the term "constant". Extension of this usage is not recommended.

EXAMPLES

equilibrium constant for a chemical reaction (which varies with temperature): K_p

Madelung constant for a particular lattice: α

A.6 Terms with general application

A.6.1 The adjectives *massic* or *specific* are added to the name of a quantity to indicate the quotient of that quantity by the mass.

EXAMPLES

massic heat capacity, specific heat capacity: c	$c = C/m$
massic volume, specific volume: v	$v = V/m$
massic entropy, specific entropy: s	$s = S/m$
massic activity, specific activity: a	$a = A/m$

A.6.2 The adjective *volumic* or the term *density* is added to the name of a quantity to indicate the quotient of that quantity by the volume (see also A.6.4).

EXAMPLES

volumic mass, mass[1] density: ϱ	$\varrho = m/V$
volumic charge, charge density: ϱ	$\varrho = Q/V$
volumic energy, energy density: w	$w = W/V$
volumic number, number density: n	$n = N/V$

1) The term mass is often omitted.

A.6.3 The adjective *lineic* or the term *linear ... density* is added to the name of a quantity to indicate the quotient of that quantity by the length.

EXAMPLES

lineic mass, linear mass[1] density: ϱ_l	$\varrho_l = m/l$
lineic electric current, linear electric current density: A	$A = I/b$

1) The term mass is often omitted.

NOTE 24 The term *linear* is also added to the name of a quantity solely to distinguish between similar quantities.

EXAMPLES

mean linear range: R	$R = \Sigma R_i/n$
mean mass range: R_ϱ	$R_\varrho = R\varrho$
linear expansion coefficient: α_l	$\alpha_l = l^{-1}\mathrm{d}l/\mathrm{d}T$
cubic expansion coefficient: α_V	$\alpha_V = V^{-1}\mathrm{d}V/\mathrm{d}T$
linear attenuation coefficient: μ	$\mu = -J^{-1}\mathrm{d}J/\mathrm{d}x$
mass attenuation coefficient: μ_m	$\mu_m = \mu/\varrho$

A.6.4 The adjective *areic* or the term *surface ... density* is added to the name of a quantity to indicate the quotient of a scalar quantity by the surface area.

EXAMPLES

areic mass, surface mass[1)] density: ϱ_A	$\varrho_A = m/A$
areic charge, surface charge density: σ	$\sigma = Q/A$

1) The term mass is often omitted.

The term *density* is added to the name of a quantity expressing a flux or current to indicate the quotient of such a quantity by the surface area (see also A.6.2).

EXAMPLES

density of heat flow rate: q	$q = \Phi/A$
electric current density: J	$J = I/A$
magnetic flux density: B	$B = \Phi/A$

A.6.5 The term *molar* is added to the name of a quantity to indicate the quotient of that quantity by the amount of substance.

EXAMPLES

molar volume: V_m	$V_\mathrm{m} = V/n$
molar internal energy: U_m	$U_\mathrm{m} = U/n$
molar mass: M	$M = m/n$

A.6.6 The term *concentration* is added to the name of a quantity, especially for a substance in a mixture, to indicate the quotient of that quantity by the total volume.

EXAMPLES

amount-of-substance[1)] concentration of B: c_B	$c_\mathrm{B} = n_\mathrm{B}/V$
molecular concentration of B: C_B	$C_\mathrm{B} = N_\mathrm{B}/V$
mass concentration of B: ϱ_B	$\varrho_\mathrm{B} = m_\mathrm{B}/V$

1) The term amount-of-substance is often omitted.

The term *spectral concentration* is used to denote a spectral distribution function (see ISO 31-6:1992, Introduction, subclause 0.5.1).

Annex B
(informative)

Guide to the rounding of numbers

B.1 Rounding means replacing the magnitude of a given number by another number called the rounded number, selected from the sequence of integral multiples of a chosen rounding interval.

EXAMPLES

1 rounding interval: 0,1
integral multiples: 12,1; 12,2; 12,3; 12,4; etc.

2 rounding interval: 10
integral multiples: 1 210 ; 1 220 ; 1 230 ; 1 240; etc.

B.2 If there is only one integral multiple nearest the given number, then that is accepted as the rounded number.

EXAMPLES

1 rounding interval: 0,1

given number	rounded number
12,223	12,2
12,251	12,3
12,275	12,3

2 rounding interval: 10

given number	rounded number
1 222,3	1 220
1 225,1	1 230
1 227,5	1 230

B.3 If there are two successive integral multiples equally near the given number, two different rules are in use.

RULE A: The even integral multiple is selected as the rounded number.

EXAMPLES

1 rounding interval: 0,1

given number	rounded number
12,25	12,2
12,35	12,4

2 rounding interval: 10

given number	rounded number
1 225,0	1 220
1 235,0	1 240

RULE B: The higher integral multiple is selected as the rounded number.

EXAMPLES

1 rounding interval: 0,1

given number	rounded number
12,25	12,3
12,35	12,4

2 rounding interval: 10

given number	rounded number
1 225,0	1 230
1 235,0	1 240

NOTE 25 Rule A is generally preferable and of special advantage when treating, for example, series of measurements in such a way that the rounding errors are minimized.

Rule B is widely used in computers.

B.4 Rounding in more than one stage by the application of the rules given above may lead to errors; it is therefore recommended *always* to round in one step.

EXAMPLE

12,251 should be rounded to 12,3 and not first to 12,25 and then to 12,2.

B.5 The rules given above should be used only if no special criteria for the selection of the rounded number have to be taken into account. For instance, in cases where safety requirements or given limits have to be respected, it may be advisable always to round in one direction.

B.6 The rounding interval should be indicated.

Annex C
(informative)

International organizations in the field of quantities and units

C.1 BIPM — CGPM — CIPM

The *International Bureau of Weights and Measures* (Bureau International des Poids et Mesures, BIPM) was set up by the *Metre Convention* (la Convention du Mètre), signed in Paris on 20 May 1875, and is situated in the Pavillon de Breteuil in Sèvres, France. Its upkeep is financed jointly by the member states of the Metre Convention. As of 1 January 1992, there were 47 member states. The task of the BIPM is to ensure worldwide harmonization of physical measurements.

The BIPM operates under the exclusive supervision of the *International Committee for Weights and Measures* (Comité International des Poids et Mesures, CIPM), consisting of 18 scientists of different member states.

The CIPM operates under the authority of the *General Conference on Weights and Measures* (Conférence Générale des Poids et Mesures, CGPM), consisting of delegates of all the member states of the Metre Convention and which meets at present every four years. The CGPM's responsibilities are

— to make the necessary arrangements required to assure the propagation and improvement of the International System of Units (SI), the successor to the Metric System;

— to confirm the results of new fundamental metrological determinations;

— to adopt important decisions concerning the organization and development of the BIPM.

The CIPM has set up since 1927 eight *Consultative Committees* (Comités Consultatifs) to advise the CIPM on specialized questions and to propose recommendations to coordinate international work carried out in their respective fields.

C.2 OIML — BIML — CIML

The *International Organization of Legal Metrology* (Organisation Internationale de Métrologie Légale, OIML) is based on an international convention established in 1955. As of 1 January 1992, the number of member countries was 49 and the number of correspondent member countries 34. The main purposes of this intergovernmental organization are

— to determine the general principles of legal metrology;

— to study the problems of legal metrology of a legislative and regulatory character;

— to establish model draft laws and regulations for measuring instruments.

The bodies of this organization are

— the *International Bureau of Legal Metrology* (Bureau International de Métrologie Légale, BIML), situated in Paris, France;

— the *International Committee of Legal Metrology* (Comité International de Métrologie Légale, CIML);

— the *International Conference on Legal Metrology* (Conférence Internationale de Métrologie Légale) together with various technical committees (Pilot Secretariats and Reporting Secretariats).

C.3 ISO — ISO/TC 12

The *International Organization for Standardization* (ISO) is a worldwide federation of national standards institutes. It was founded in 1946. ISO members are the national standards bodies of different countries. As of 31 December 1991, there were 72 member bodies and 18 correspondent members.

The *ISO Central Secretariat* coordinates the activities of ISO. It is located in Geneva, Switzerland.

For the development of International Standards ISO operates (Dec. 1991) 174 technical committees (TCs), 630 subcommittees (SCs), and 1 827 working groups (WGs).

The work of the ISO technical committees has resulted in the publication of about 8 200 International Standards. The secretariats of the ISO technical committees and subcommittees are distributed among the member bodies of ISO.

ISO Technical Committee 12, ISO/TC 12, *Quantities, units, symbols, conversion factors*, is ISO's designated committee for developing International Standards for quantities and units in science and technology. ISO/TC 12 was created in 1947 and its secretariat was located in Denmark. In 1982 the secretariat was transferred to Sweden.

The International Standards ISO 31 (14 parts) and ISO 1000 and ISO Standards Handbook 2 are the results of the work in this committee.

C.4 IEC — IEC/TC 25

The *International Electrotechnical Commission* (IEC) was founded in 1906. It is the authority for world standards for electrical and electronic engineering. As of 1 January 1992, the IEC was composed of national committees from 42 countries.

The *IEC Central Office* is located close to the ISO Central Secretariat in Geneva, Switzerland.

The standards are prepared by 84 technical committees, 117 subcommittees and about 750 working groups.

IEC Technical Committee 25, IEC/TC 25, *Quantities and units and their letter symbols*, has as its scope the preparation of International Standards on quantities and units to be used in electrical technology. Such standards may relate to their definitions, names, letter symbols and use, to the relations in which they appear and to the signs and symbols used with them.

Publications: IEC 27, *Letter symbols to be used in electrical technology*, parts 1 to 4.

C.5 IUPAP — SUN

The *International Union of Pure and Applied Physics* (IUPAP) was created in 1922 in Brussels. Its aims include the following:

- the stimulation of international cooperation in physics;
- the promotion of international agreements on the use of symbols, units, nomenclature and standards.

In each country the IUPAP is represented by a national committee. The number of member countries of the IUPAP was 43 as of 1 January 1992. The *General Assembly* directs the work of the Union, appoints the Executive Committee and sets up commissions pertinent to the work of the Union.

In 1931 the *Commission for Symbols, Units and Nomenclature* (SUN Commission) was created to promote international agreement and make international recommendations in the field of symbols, units and nomenclature. In 1978 the IUPAP decided to amalgamate the SUN Commission with its Commission on Atomic Masses and Fundamental Constants. The most recent publication is I.U.P.A.P.-25 (1987) entitled: *Symbols, Units, Nomenclature and Fundamental Constants in Physics*, published in 1987 to replace U.I.P.20 (1978).

C.6 IUPAC — IDCNS

The *International Union of Pure and Applied Chemistry* (IUPAC), established in 1919, is the international body which represents chemistry amongst the other disciplines of science. Its objectives are

- to promote continuing cooperation amongst the chemists of its member countries;
- to study topics of international importance to pure and applied chemistry which need regulation, standardization or codification;
- to cooperate with other international organizations which deal with topics of a chemical nature;
- to contribute to the advancement of pure and applied chemistry in all its aspects.

As of 1 January 1992, there were 44 member countries and, in addition, 13 observer countries. IUPAC also has an affiliate membership scheme in which more than 5 000 chemists are enrolled. The work of IUPAC is directed by its *General Assembly* which meets biennially, appoints an Executive Committee, and sets up relevant Commissions.

IUPAC has its Secretariat in Oxford (UK).

IUPAC is recognized throughout the world as the international authority on chemical nomenclature, terminology, symbols, the molar masses of the elements and related matters. Its Commission I.1 of the Division of Physical Chemistry, on Symbols, Terminology and Units, is chiefly responsible for recommendations relevant to the work of ISO/TC 12, but other Commissions (especially Commission VII.2 of the Division of Clinical Chemistry) also contribute to the field. Their work is correlated by the *Interdivisional Committee on Nomenclature and Symbols* (IDCNS).

Publication: *Quantities, Units and Symbols in Physical Chemistry*, International Union of Pure and Applied Chemistry, Blackwell Scientific Publications, Oxford (1988).

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