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December 1993

Units

Names and symbols

DIN 1301 Part 1

Einheiten; Einheitennamen, Einheitenzeichen

Supersedes December 1985 edition.

This standard substantially reproduces the content of ISO 1000:1992 (cf. Explanatory notes). It also incorporates the resolutions of the 19th General Conference of Weights and Measures (CGPM) held in 1991.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

1 Scope and field of application

This standard presents the units of the International System of Units (SI) together with a number of other recommended units and the prefixes used to express decimal multiples and sub-multiples.

Commonly used multiples and sub-multiples of SI units and of other recommended units are listed in DIN 1301 Part 2.

Conversion factors for units that are no longer to be used are given in DIN 1301 Part 3.

Supplement 1 to DIN 1301 Part 1 lists other names and symbols that are used in the same way as units.

2 Concepts

2.1 Units and unit systems

See DIN 1313.

2.2 SI units

SI units comprise base SI units and derived SI units.

NOTE: The name *Système International d'Unités* (International System of Units) and the symbol SI were adopted at the 11th General Conference of Weights and Measures (CGPM) held in 1960. Full information about the International System of Units is given in the brochure *Le Système International d'Unités (SI)* published in French with an authorized English translation by the International Bureau of Weights and Measures.

2.3 Base SI units

The base SI units are listed in table 1. All other units in the system can be derived from them.

See Appendix A for definitions of the base SI units.

2.4 Derived SI units

Derived SI units are coherent units, i.e. they are obtained as products, quotients/ratios or exponential products of base SI units formed with the factor 1.

EXAMPLES:

$\frac{kg}{s}$ for the mass flow rate

$A \cdot s$ for the electric charge

$\frac{kg \cdot m}{s^2}$ for force

Derived SI units that have special names and symbols are listed in table 2.

Table 1: Base SI units

No.	Quantity	Base SI unit Name	Symbol
1.1	Length	metre	m
1.2	Mass	kilogram	kg
1.3	Time	second	s
1.4	Electric current	ampere	A
1.5	Thermodynamic temperature	kelvin	K
1.6	Amount of substance	mole	mol
1.7	Luminous intensity	candela	cd

3 Representation of derived SI units

Derived SI units may be expressed in terms of base SI units or in some cases designated by way of a special name.

To facilitate the distinction between quantities of the same dimension, preference may be given to particular names or combinations.

For example:

- the newton metre (N · m) for the moment of force, instead of the joule,
- the hertz (Hz) for the frequency of a periodic phenomenon, and the becquerel (Bq) for the activity of a radioactive substance, instead of the reciprocal second (1/s).

Continued on pages 2 to 6.

Table 2: Derived SI units with special names and symbols

No.	Quantity	SI derived unit Name	Symbol	Expressed in terms of base units
2.1	plane angle	radian	rad	$1\ \text{rad} = 1\,\frac{\text{m}}{\text{m}}$
2.2	solid angle	steradian	sr	$1\ \text{sr} = 1\,\frac{\text{m}^2}{\text{m}^2}$
2.3	frequency of a periodic phenomenon	hertz	Hz	$1\ \text{Hz} = \frac{1}{\text{s}}$
2.4	activity of a radionuclide	becquerel	Bq	$1\ \text{Bq} = \frac{1}{\text{s}}$
2.5	force	newton	N	$1\ \text{N} = 1\,\frac{\text{J}}{\text{m}} = 1\,\frac{\text{m}\cdot\text{kg}}{\text{s}^2}$
2.6	pressure, mechanical stress	pascal	Pa	$1\ \text{Pa} = 1\,\frac{\text{N}}{\text{m}^2} = 1\,\frac{\text{kg}}{\text{m}\cdot\text{s}^2}$
2.7	energy, work, heat	joule	J	$1\ \text{J} = 1\ \text{N}\cdot\text{m} = 1\ \text{W}\cdot\text{s} = 1\,\frac{\text{m}^2\cdot\text{kg}}{\text{s}^2}$
2.8	power, radiant flux	watt	W	$1\ \text{W} = 1\,\frac{\text{J}}{\text{s}} = 1\ \text{V}\cdot\text{A} = 1\,\frac{\text{m}^2\cdot\text{kg}}{\text{s}^3}$
2.9	absorbed dose	gray	Gy	$1\ \text{Gy} = 1\,\frac{\text{J}}{\text{kg}} = 1\,\frac{\text{m}^2}{\text{s}^2}$
2.10	dose equivalent	sievert	Sv	$1\ \text{Sv} = 1\,\frac{\text{J}}{\text{kg}} = 1\,\frac{\text{m}^2}{\text{s}^2}$
2.11	electric charge, quantity of electricity	coulomb	C	$1\ \text{C} = 1\ \text{A}\cdot\text{s}$
2.12	electric potential, potential difference	volt	V	$1\ \text{V} = 1\,\frac{\text{J}}{\text{C}} = 1\,\frac{\text{m}^2\cdot\text{kg}}{\text{s}^3\cdot\text{A}}$
2.13	electric capacitance	farad	F	$1\ \text{F} = 1\,\frac{\text{C}}{\text{V}} = 1\,\frac{\text{s}^4\cdot\text{A}^2}{\text{m}^2\cdot\text{kg}}$
2.14	electric resistance	ohm	Ω	$1\ \Omega = 1\,\frac{\text{V}}{\text{A}} = 1\,\frac{\text{m}^2\cdot\text{kg}}{\text{s}^3\cdot\text{A}^2}$
2.15	electric conductance	siemens	S	$1\ \text{S} = \frac{1}{\Omega} = 1\,\frac{\text{s}^3\cdot\text{A}^2}{\text{m}^2\cdot\text{kg}}$
2.16	magnetic flux	weber	Wb	$1\ \text{Wb} = 1\ \text{V}\cdot\text{s} = 1\,\frac{\text{m}^2\cdot\text{kg}}{\text{s}^2\cdot\text{A}}$
2.17	magnetic flux density	tesla	T	$1\ \text{T} = \frac{\text{Wb}}{\text{m}^2} = 1\,\frac{\text{kg}}{\text{s}^2\cdot\text{A}}$
2.18	inductance	henry	H	$1\ \text{H} = 1\,\frac{\text{Wb}}{\text{A}} = 1\,\frac{\text{m}^2\cdot\text{kg}}{\text{s}^2\cdot\text{A}^2}$
2.19	Celsius temperature[1])	degree Celsius	°C	1 °C = 1 K
2.20	luminous flux	lumen	lm	$1\ \text{lm} = 1\ \text{cd}\cdot\text{sr}$
2.21	illuminance	lux	lx	$1\ \text{lx} = 1\,\frac{\text{lm}}{\text{m}^2} = 1\,\frac{\text{cd}\cdot\text{sr}}{\text{m}^2}$

[1]) See Note 2 to clause A.5.

4 Non-SI units

Table 3: Non-SI units of general application

No.	Quantity	Name	Symbol	Definition
3.1	plane angle	perigon gon degree minute second	[2] gon ° [3] ′ [3] ″ [3]	1 perigon = 2 π rad 1 gon = (π/200) rad 1° = (π/180) rad 1′ = (1/60)° 1″ = (1/60)′
3.2	volume	litre	l, L [4]	1 l = 1 dm^3 = 1 L
3.3	time	minute hour day	min [3] h [3] d [3]	1 min = 60 s 1 h = 60 min 1 d = 24 h
3.4	mass	tonne/metric ton gram	t g [5]	1 t = 10^3 kg = 1 Mg 1 g = 10^{-3} kg
3.5	pressure	bar	bar	1 bar = 10^5 Pa

[2]) A symbol for this unit has not yet been specified in international standards.
[3]) Not to be used with prefixes.
[4]) Both unit symbols for the litre are equally valid.
[5]) The gram is both a base unit in the CGS system and an SI unit.

Table 4: Non-SI units of restricted application

No.	Quantity and field of application	Name	Symbol	Definition, relationship
4.1	Refractive power of optical systems	dioptre	dpt [6]	1 dioptre is equal to the refractive power of an optical system with a focal length of 1 m in a medium with a refractive index of 1. $1\ \text{dpt} = \frac{1}{\text{m}}$
4.2	Area of land or property	are hectare	a ha [3]	1 a = 10^2 m^2 1 ha = 10^4 m^2
4.3	Unit of cross section (atomic physics)	barn	b	1 b = 10^{-28} m^2
4.4	Mass (atomic physics)	atomic mass unit	u	The unified atomic mass unit is equal to 1/12th of the mass of an atom of the nuclide ^{12}C: 1 u = 1,6605402 · 10^{-27} kg The standard deviation is: s = 1,0 · 10^{-33} kg (cf. CODATA Bulletin No. 63, November 1986)
4.5	Mass (precious stones)	metric karat	[7]	1 metric karat = 0,2 g
4.6	Linear density (textiles fibres and yarns)	tex	tex	$1\ \text{tex} = 1\ \frac{\text{g}}{\text{km}}$
4.7	Blood pressure and pressure of other body fluids (medicine)	millimetres of mercury column	mmHg [3]	1 mmHg = 133,322 Pa
4.8	Energy (atomic physics)	electronvolt	eV	1 electronvolt is the kinetic energy acquired by an electron on passing through a potential difference of 1 volt in vacuum: 1 eV = 1,602 177 33 · 10^{-19} J The standard deviation is: s = 4,9 · 10^{-26} J (cf. CODATA Bulletin No. 63, November 1986)
4.9	Reactive power (electrical energy technology)	var	var	1 var = 1 W (cf. DIN 40110 Part 1*))

[3]) Not to be used with prefixes.
[6]) This symbol has not been specified in international standards.
[7]) A symbol for this unit has not yet been specified in international standards. Hitherto, the symbol Kt has been used.
*) At present at the stage of draft.

5 Decimal multiples and sub-multiples of units

5.1 Decimal multiples and sub-multiples of units shall be represented by means of the prefixes and prefix symbols given in table 5. These prefixes and prefix symbols shall only be used in conjunction with units.

5.2 A prefix symbol shall be written immediately in front of the unit symbol with which it then forms the symbol of a new compound unit.

An exponent placed after the unit symbol also applies to the prefix symbol.

EXAMPLES:

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

$$1\ \mu\mathrm{s}^{-1} = \frac{1}{\mu\mathrm{s}} = \frac{1}{10^{-6}\,\mathrm{s}} = 10^6\,\mathrm{s}^{-1} = 10^6\,\mathrm{Hz} = 1\ \mathrm{MHz}$$

Table 5: Prefixes and prefix symbols for decimal multiples and sub-multiples of units ('SI prefixes')

No.	Prefix	Prefix symbol	Multiplication factor
5.1	yocto	y	10^{-24}
5.2	zepto	z	10^{-21}
5.3	atto	a	10^{-18}
5.4	femto	f	10^{-15}
5.5	pico	p	10^{-12}
5.6	nano	n	10^{-9}
5.7	micro	µ	10^{-6}
5.8	milli	m	10^{-3}
5.9	centi	c	10^{-2}
5.10	deci	d	10^{-1}
5.11	deca	da	10^{1}
5.12	hecto	h	10^{2}
5.13	kilo	k	10^{3}
5.14	mega	M	10^{6}
5.15	giga	G	10^{9}
5.16	tera	T	10^{12}
5.17	peta	P	10^{15}
5.18	exa	E	10^{18}
5.19	zetta	Z	10^{21}
5.20	yotta	Y	10^{24}

5.3 Compound units shall not be formed using more than one prefix.

EXAMPLE:

$1 \cdot 10^{-9}$ m may be expressed as 1 nm (nanometre) but not as 1 mµm (millimicrometre).

5.4 In the case of the base SI unit kilogram (kg), prefixes are not to be used with the base unit but with the unit gram (g).

EXAMPLE:

milligram (mg), not microkilogram (µkg).

6 Use of units with prefixes

6.1 When indicating quantities, it may be expedient to choose multiples so that the numerical values lie between 0,1 and 1000.

EXAMPLES:

$1{,}2 \cdot 10^4$ N may be written as 12 kN, 0,003 94 m as 3,94 mm, 1 401 Pa as 1,401 kPa, $3{,}1 \cdot 10^{-8}$ s as 31 ns, and $6 \cdot 10^{18}$/l as 6 al^{-1}

6.2 Within the same table of values, only one multiple should be used with a given quantity, even if that means that some numerical values will then be outside the suggested range 0,1 to 1000. In certain applications, the same multiple may be used exclusively with a particular quantity, e.g. the millimetre in mechanical engineering drawings.

7 Rules for writing symbols

7.1 Unit symbols shall generally be written in lower case letters, except when the unit name derives from a proper name (exception: L).

7.2 Irrespective of the type used in the rest of the text, unit symbols shall be printed upright (cf. DIN 1338). In the expression of a quantity, they shall follow the numerical value, with a space being left between value and symbol except in the case of the symbols °, ′ and ″.

7.3 Compound units formed as products of units shall be indicated in one of the following ways:

N · m, N m.

7.4 When a symbol is used both as a unit symbol and as a prefix, the factors shall be written in such a way that ambiguity is avoided.

EXAMPLE:

The unit 'newtonmetre' for the moment of force should be written N m or m · N, but not mN, in order to distinguish it from the millinewton (mN).

7.5 Compound units formed as quotients of units shall be indicated in one of the following ways:

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

If a solidus is used in fractions and more than one unit symbol occurs in the same denominator, parentheses shall be inserted to avoid any ambiguity.

EXAMPLE:

The SI unit for thermal conductivity is not to be written W/K/m, but

$$\mathrm{W} \cdot \mathrm{K}^{-1} \cdot \mathrm{m}^{-1}\ \text{or}\ \frac{\mathrm{W}}{\mathrm{K} \cdot \mathrm{m}}\ \text{or}\ \mathrm{W/(K \cdot m)}.$$

If a unit is a power with a negative exponent, it may also be written as a fraction with a 1 in the numerator.

EXAMPLE:

$$\mathrm{s}^{-1} = \frac{1}{\mathrm{s}}$$

The 1 should be omitted when the unit is multiplied with a number.

EXAMPLE:

$$3000\ \mathrm{s}^{-1} = \frac{3000}{\mathrm{s}}$$

7.6 For the reproduction of unit names and prefixes in data processing equipment with limited character sets, see DIN 66030.

Appendix A

There follow the definitions of the base units of the International System of Units as established by the General Conference of Weights and Measures.

A.1 Metre

The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second. (17th CGPM, 1983)

A.2 Kilogram

The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram. (3rd CGPM, 1901)

A.3 Second

The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom. (13th CGPM, 1967)

A.4 Ampere

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to $2 \cdot 10^{-7}$ newton per metre of length. (CIPM, 1946, adopted by the 9th CGPM, 1948)

A.5 Kelvin

The kelvin, unit of thermodynamic temperature, is the fraction 1/273,16 of the thermodynamic temperature of the triple point of water. (13th CGPM, 1967)

NOTE 1: The 13th CGPM (1967) also decided that the unit kelvin and its symbol K should be used to express an interval or a difference in temperature.

NOTE 2: In addition to the thermodynamic temperature (denoted T), expressed in kelvins, use is also made of Celsius temperature (denoted t) defined by the equation $t = T - T_0$, where $T_0 = 273{,}15$ K by definition. To express Celsius temperature, the unit 'degree Celsius', which is equal to the unit 'kelvin' is used; in this case, 'degree Celsius' is a special name used in place of 'kelvin'. An interval or difference of Celsius temperature can, however, be expressed in kelvins as well as in degrees Celsius (cf. DIN 1345).

A.6 Mole

The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0,012 kilograms of ^{12}C. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles. (14th CGPM, 1971)

A.7 Candela

The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency $540 \cdot 10^{12}$ hertz and that has a radiant intensity in that direction of 1/683 watt per steradian. (16th CGPM, 1979)

Standards and other documents referred to

DIN 1301 Part 2	Units; sub-multiples and multiples for general use
DIN 1301 Part 3	Units; conversion of units whose use is deprecated
Supplement 1 to DIN 1301 Part 1	Units; names and symbols used similarly to units
DIN 1313	Physical quantities and equations; concepts, methods of writing
DIN 1338	Writing and typesetting of formulae
DIN 1345	Thermodynamics; basic concepts
DIN 40110 Part 1	Quantities used in alternating current theory; two-wire systems
DIN 66030	Information technology; representation of names of units to be used in systems with limited character sets
ISO 1000:1992	SI units and recommendations for the use of their multiples and of certain other units

Le Système Internationale d'Unités (SI), Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92312 Sèvres Cedex

CODATA Bulletin No. 63, November 1986, Pergamon Press, Pergamon Journals Ltd, Headington Hill Hall, Oxford OX30BW, UK

Other relevant standard

DIN 1305 Mass, force, weight force, weight, load; concepts

Previous editions

DIN 1301: 07.25, 04.28, 03.33, 06.55, 11.61, 02.62x, 01.66x, 11.71; DIN 1301 Part 1: 02.78, 10.78, 12.85; DIN 1339: 07.46, 04.58, 09.68, 11.71; DIN 1357: 04.58x, 08.66, 12.67, 11.71.

Amendments

The following amendments have been made to the December 1985 edition:

a) The new prefixes zepto, zetta, yocto and yotta have been included in table 5.

b) The values for the unified atomic mass unit and the electronvolt have been altered in line with CODATA Bulletin No. 63.

Explanatory notes

The present standard reproduces the substance of clauses 1 to 5 and Annex B of International Standard ISO 1000. It differs from ISO 1000 in the following respects.

The units radian and steradian are not included here with the 'supplementary SI units' but are treated as derived SI units with a special name. In line with the EC Directive 80/181, the units barn, metric karat, millimetre mercury column, tex and var have been included, and the astronomical unit and parsec have been omitted. The method of writing units with the multiplication stop on the line (e.g. N . m) (cf. note 2 in ISO 1000) has not been adopted, as this may cause confusion in the case of numbers and should thus not be standardized in the case of units.

The examples of decimal multiples and sub-multiples of units given in Annex A of ISO 1000 are to be found in DIN 1301 Part 2.

International Patent Classification

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G 11 B 005/00