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American National Standard for Metric Practice

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(Quantities, Units, and Letter Symbols)

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IEEE/ASTM SI 10™-2016
(Revision of
IEEE/ASTM SI 10-2010)

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Abstract: Guidance for the use of the modern metric system is given. Known as the International System of Units (abbreviated SI), the system is the basis for worldwide standardization of measurement units. Information is included on SI, a list of units recognized for use with SI, and a list of conversion factors, together with general guidance on proper style and usage.

Keywords: conversion factors, International System, International System of Units, metric practice, metric system, rounding, SI, SI 10, Système International d'Unités

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Introduction

This introduction is not part of IEEE/ASTM SI 10-2016, American National Standard for Metric Practice.

Any measurable physical quantity can be represented in the International System of Units (SI) with the aid of just seven *base units*—the units for the quantities length, mass, time, electric current, temperature, amount of substance, and luminous intensity—or by combinations (called *derived units*) of these seven. For example, the unit of speed can be expressed by the unit of length divided by the unit of time. This standard shows first the two classes of units (base and derived) that make up the SI, together with the standard symbols that may be used to represent them. Prefixes that allow the formation of decimal multiples and submultiples are explained. Notes on the proper use of the SI units and symbols in many applications follow.

Annex A includes lists of many units from non-SI systems with the appropriate SI units that should be substituted and numerical conversion factors. Other annexes include rules for conversion and rounding (Annex B), a discussion of the advantages of SI units with definitions where appropriate (Annex C), a history of the development of the system (Annex D), a discussion of quantities relating to chemical solutions (Annex E), and a bibliography of source documents (Annex F).

Contents

American National Standard for Metric Practice

1. Scope

This document is the primary American National Standard on application of the metric system. It emphasizes use of the International System of Units (SI), which is the modern, internationally accepted metric system. It includes information on SI, a limited list of units recognized for use with SI, and a list of conversion factors, together with general guidance on style and usage. It also lists older "metric" units that shall no longer be used. The word *primary* implies that other metric standards in the United States should be consistent with this document.

2. SI units and symbols

2.1 Classes of units

2.1.1 Base units

SI is built upon the seven well-defined base quantities of Table 1, which by convention are regarded as independent, and upon the seven base units for these quantities. The definitions of the base units are given in C.3. Throughout this document, unless otherwise noted, the word *quantity* means a measurable attribute of a phenomenon or of matter.

Table 1—SI base units

Quantity name	Typical quantity symbol[a]	Unit name	Unit symbol
length	*l, x, r,* etc.	meter	m
mass	*m*	kilogram	kg
time	*t*	second	s
electric current	*I, i*	ampere	A
thermodynamic temperature	*T*	kelvin	K
amount of substance	*n*	mole	mol
luminous intensity	I_v	candela	cd

[a] The symbols for quantities are suggestions only and alternative symbols may be used, as indicated for length and electric current—see 3.5.1.3 c).

2.1.2 Derived units

Derived units are formed by combining base units according to the algebraic relations linking the corresponding quantities. The symbols for derived units are obtained by means of the mathematical signs for multiplication, division, and use of exponents. Table 2 gives examples of derived units and shows how they are formed from base units.

Table 2—Examples of SI derived units expressed in terms of base units

Quantity name	Typical quantity symbol[a]	Unit name	Unit symbol
area	*A*	square meter	m^2
volume	*V*	cubic meter	m^3
speed, velocity	*v*, *υ*, *u*	meter per second	m/s
acceleration	*a*	meter per second squared	m/s^2
wavenumber	σ, *k*	reciprocal meter	m^{-1}
density, mass density	*ρ*	kilogram per cubic meter	kg/m^3
specific volume	*v*	cubic meter per kilogram	m^3/kg
current density	*j*	ampere per square meter	A/m^2
magnetic field strength	*H*	ampere per meter	A/m
concentration (of amount of substance)	*c*	mole per cubic meter	mol/m^3
luminance	L_v	candela per square meter	cd/m^2

[a] The symbols for quantities are suggestions only and alternative symbols may be used, as indicated for speed and wavenumber—see 3.5.1.3 c).

For convenience, certain derived units have been given special names and symbols. Those that are approved by the General Conference on Weights and Measures (abbreviated CGPM from its name in French; see **Error! Reference source not found.**), and are therefore formally part of the SI, are listed in Table 3. Definitions are provided in C.4.

Table 3—SI derived units with special names and symbols

Quantity name	Unit name	Unit symbol	Expressed in terms of other SI units	Expressed in terms of SI base units
angle, plane	radian	rad	1	$m \cdot m^{-1} = 1$ [See NOTE]
angle, solid	steradian	sr	1	$m^2 \cdot m^{-2} = 1$ [See NOTE]
frequency (of a periodic phenomenon)	hertz	Hz		s^{-1}
force	newton	N		$kg \cdot m \cdot s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$kg \cdot m^{-1} \cdot s^{-2}$
energy, work, quantity of heat	joule	J	$N \cdot m$	$kg \cdot m^2 \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$kg \cdot m^2 \cdot s^{-3}$
electric charge, quantity of electricity	coulomb	C		$s \cdot A$
electric potential difference, electromotive force	volt	V	W/A	$kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}$
capacitance	farad	F	C/V	$kg^{-1} \cdot m^{-2} \cdot s^4 \cdot A^2$
electric resistance	ohm	Ω	V/A	$kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}$
electric conductance	siemens	S	A/V	$kg^{-1} \cdot m^{-2} \cdot s^3 \cdot A^2$
magnetic flux	weber	Wb	$V \cdot s$	$kg \cdot m^2 \cdot s^{-2} \cdot A^{-1}$
magnetic flux density	tesla	T	Wb/m^2; $N/(A \cdot m)$	$kg \cdot s^{-2} \cdot A^{-1}$
inductance	henry	H	Wb/A	$kg \cdot m^2 \cdot s^{-2} \cdot A^{-2}$
luminous flux	lumen	lm	$cd \cdot sr$	$m^2 \cdot m^{-2} \cdot cd = cd$
illuminance	lux	lx	lm/m^2	$m^2 \cdot m^{-4} \cdot cd = m^{-2} \cdot cd$
activity (referred to a radionuclide)	becquerel	Bq		s^{-1}
absorbed dose, specific energy imparted, kerma	gray	Gy	J/kg	$m^2 \cdot s^{-2}$
dose equivalent, ambient dose equivalent, directional dose equivalent, personal dose equivalent, organ equivalent dose	sievert	Sv	J/kg	$m^2 \cdot s^{-2}$
catalytic activity	katal	kat		$s^{-1} \cdot mol$

NOTE—If the SI units are considered as a mathematical group, group theory requires that the number 1 be included with the base units. The CGPM has not yet adopted this position.[1]

It is sometimes convenient to express derived units in terms of other derived units with special names. Some examples appear in Table 3 and additional examples are given in Table 4. Note that although the expression of a derived unit in terms of the SI base units is unique, there are frequently alternative ways to express a derived unit using other derived units.

[1] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.