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Quantities and units - Part 6: Electromagnetism (IEC 80000-6:2022)

Größen und Einheiten - Teil 6: Elektromagnetismus (IEC 80000-6:2022)

Grandeurs et unités - Partie 6: Electromagnétisme (IEC 80000-6:2022)

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Grandeurs et unités - Partie 6: Electromagnétisme
(IEC 80000-6:2022)

Größen und Einheiten - Teil 6: Elektromagnetismus
(IEC 80000-6:2022)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

EN IEC 80000-6:2022 (E)**European foreword**

The text of document 25/732/FDIS, future edition 2 of IEC 80000-6, prepared by IEC/TC 25 "Quantities and units" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 80000-6:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2023-09-21
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This document supersedes EN 80000-6:2008 and all of its amendments and corrigenda (if any).

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The text of the International Standard IEC 80000-6:2022 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standard indicated:

IEC 60027-1 NOTE Harmonized as EN 60027-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Quantities and units –
Part 6: Electromagnetism**

**Grandeurs et unités –
Partie 6: Électromagnétisme**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

QUANTITIES AND UNITS –**Part 6: Electromagnetism****FOREWORD**

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IEC 80000-6 has been prepared by IEC technical committee 25: Quantities and units, and their letter symbols in close cooperation with ISO/TC 12, Quantities and units. It is an International Standard.

This second edition of IEC 80000-6 cancels and replaces the first edition published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) With the new definitions in SI, some previously exact values for quantities now must be determined experimentally while other quantities are given as exact values;
- b) Item 6-2.2, elementary charge added;
- c) Item 6-11.4, induced voltage, added;
- d) Index of entries added;
- e) Editorial alignment to other parts of the IEC and ISO 80000 series.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|-------------|------------------|
| 25/732/FDIS | 25/740/RVD |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

IEC 80000 consists of the following parts, under the general title *Quantities and units*:

- 1) *Part 6: Electromagnetism*
- 2) *Part 13: Information science and technology*
- 3) *Part 15: Logarithmic and related quantities, and their units*
- 4) *Part 16: Printing and writing rules*
- 5) *Part 17: Time dependency*

The following parts are published by ISO:

- 1) *Part 1: General*
- 2) *Part 2: Mathematical signs and symbols to be used in the natural sciences and technology*
- 3) *Part 3: Space and time*
- 4) *Part 4: Mechanics*
- 5) *Part 5: Thermodynamics*
- 6) *Part 7: Light*
- 7) *Part 8: Acoustics*
- 8) *Part 9: Physical chemistry and molecular physics*
- 9) *Part 10: Atomic and nuclear physics*
- 10) *Part 11: Characteristic numbers*
- 11) *Part 12: Condensed matter physics*

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

0.1 Tables of quantities

The names in English of the most important quantities within the field of this document are given together with their symbols and, in most cases, their definitions. The definitions are given for identification of the quantities in the International System of Quantities (ISQ), listed in Table 1; they are not intended to be complete.

The scalar, vectorial or tensorial character of quantities is pointed out, especially when this is needed for the definitions.

In most cases, only one name and only one symbol for the quantity are given; where two or more names or two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing. When two types of italic letters exist (for example as with ϑ and θ ; φ and ϕ ; a and α ; g and g) only one of these is given. This does not mean that the other is not equally acceptable. It is recommended that such variants should not be given different meanings. A symbol within parenthesis implies that it is an alternative symbol, to be used when, in a particular context, the main symbol is in use with a different meaning.

0.2 Units

0.2.1 General

The names of units for the corresponding quantities are given together with the international symbols and the definitions. These unit names are language-dependent, but the symbols are international and the same in all languages. For further information, see the SI Brochure (9th edition 2019) from BIPM and ISO 80000-1.

The units are arranged in the following way:

- a) The base SI units are given first. The SI units have been adopted by the General Conference on Weights and Measures (Conférence Générale des Poids et Mesures, CGPM). The use of base SI units, and their decimal multiples and submultiples formed with the SI prefixes are recommended, although the decimal multiples and submultiples are not explicitly mentioned. The order of the units is kg, m, s, A, K, mol, cd.
- b) Some non-SI units are then given, being those accepted by the International Committee for Weights and Measures (Comité International des Poids et Mesures, CIPM), or by the International Organization of Legal Metrology (Organisation Internationale de Métrologie Légale, OIML), or by ISO and IEC, for use with the SI.
- c) Non-SI units that are not recommended are given only in annexes in some parts of ISO 80000 and IEC 80000. These annexes are informative, in the first place for the conversion factors, and are not integral parts of the standard. These deprecated units are arranged in two groups:
 - 1) units in the CGS system with special names, see Annex A;
 - 2) units based on the foot, pound, and some other related units.

0.2.2 Remark on units for quantities of dimension one, or dimensionless quantities

The coherent unit for any quantity of dimension one, also called a dimensionless quantity, is the number one, symbol 1. When the value of such a quantity is expressed, the unit symbol 1 is generally not written out explicitly.

EXAMPLE

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

Prefixes shall not be used to form multiples or submultiples of this unit. Instead of prefixes, powers of 10 are recommended.

EXAMPLE

Reynolds number $Re = 1,32 \times 10^3$

Considering that plane angle is generally expressed as the ratio of two lengths and solid angle as the ratio of two areas, in 1995 the CGPM specified that, in the SI, the radian, symbol rad, and steradian, symbol sr, are dimensionless derived units. This implies that the quantities plane angle and solid angle are considered as derived quantities of dimension one. The units radian and steradian are thus equal to one; they may either be omitted, or they may be used in expressions for derived units to facilitate distinction between quantities of different kinds, but having the same dimension.

0.3 Numerical statements in this document

The sign = is used to denote "is exactly equal to" and the sign \approx is used to denote "is approximately equal to".

Numerical values of physical quantities that have been experimentally determined always have an associated measurement uncertainty. This uncertainty should always be specified. In this document, the magnitude of the uncertainty is represented as in the following example.

EXAMPLE

$l = 2,347\ 82(32)\ \text{m}$

In this example, $l = a(b)\ \text{m}$, the numerical value of the uncertainty b indicated in parentheses is assumed to apply to the last (and least significant) digits of the numerical value a of the length l . This notation is used when b represents one standard uncertainty (estimated standard deviation) in the last digits of a . The numerical example given above can be interpreted to mean that the best estimate of the numerical value of the length l , when l is expressed in the unit metre, is 2,347 82 and that the unknown value of l is believed to lie between $(2,347\ 82 - 0,000\ 32)\ \text{m}$ and $(2,347\ 82 + 0,000\ 32)\ \text{m}$ with a probability determined by the standard uncertainty 0,000 32 m and the probability distribution of the values of l .

0.4 Special remarks

0.4.1 General

The items given in IEC 80000-6 are generally in conformity with the International Electrotechnical Vocabulary (IEV), especially IEC 60050-121 and IEC 60050-131. For each quantity, the reference to IEV is given in the form: "See IEC 60050-121:20XX, 121-xx-xxx."

The font used for text is sans serif; that used for quantities is serif.

0.4.2 System of quantities

For electromagnetism, several different systems of quantities have been developed and used depending on the number and the choice of base quantities on which the system is based. However, in electromagnetism and electrical engineering, only the International System of Quantities, ISQ, and the associated International System of Units, SI, are acknowledged and are reflected in the standards of ISO and IEC. The SI has seven base units, among them are the kilogram (kg), the metre (m), the second (s), and the ampere (A).

0.4.3 Sinusoidal quantities

For quantities that vary sinusoidally with time, and for their complex representations, the IEC has standardized two ways to build symbols. Capital and lowercase letters are generally used for electric current (item 6-1) and for voltage (item 6-11.3), and additional symbols for other quantities. These are given in IEC 60027-1.

EXAMPLE 1

The sinusoidal variation with time of an electric current (item 6-1) can be expressed in real representation as

$$i = \sqrt{2} I \cos(\omega t - \varphi)$$

and its complex representation (termed phasor) is expressed as

$$i = I e^{-j\varphi}$$

where i is the instantaneous value of the current, I , is its root-mean-square (RMS) value (see 0.4.4), $(\omega t - \varphi)$ is the phase, φ is the initial phase, and j is the imaginary unit ($j^2 = -1$), in mathematics often denoted by i .

EXAMPLE 2

The sinusoidal variation with time of a magnetic flux (item 6-22.1) can be expressed in real representation as

$$\Phi = \hat{\Phi} \cos(\omega t - \phi) = \sqrt{2} \Phi_{\text{eff}} \cos(\omega t - \phi)$$

where Φ is the instantaneous value of the flux, $\hat{\Phi}$ is its peak value and Φ_{eff} is its RMS value.

0.4.4 Root-mean-square value, RMS value

For a time-dependent quantity a , the positive square root of the mean value of the square of the quantity taken over a given time interval is called root-mean-square value, i.e.

$$\sqrt{\frac{1}{T} \int_0^T a^2 dt}$$

The root-mean-square value of a periodic quantity is usually taken over an integration interval, the range of which is the period multiplied by a natural number. For a sinusoidal quantity $a(t) = \hat{A} \cos(\omega t + \varphi)$, the root-mean-square value is $\hat{A}/\sqrt{2}$.

The root-mean-square value of a quantity may be denoted by adding one of the subscripts "eff" or "RMS" to the symbol of the quantity. In electrical technology, the root-mean-square values of electric current $i(t)$ and voltage $u(t)$ are usually denoted I and U , respectively.