

Quantities and units —

Part 5: Electricity and magnetism

ICS 01.060

National foreword

This British Standard reproduces verbatim ISO 31-5:1992, including amendment 1:1998, and implements it as the UK national standard. It supersedes BS 5775-5:1993 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee SS/7, General metrology, quantities, units and symbols, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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Summary of pages

This document comprises a front cover, an inside front cover, the ISO title page, pages ii to vi, pages 1 to 28, an inside back cover and a back cover.

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Amendments issued since publication

Amd. No.	Date	Comments

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 16 July 2004

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ISBN 0 580 44073 7

INTERNATIONAL STANDARD

ISO
31-5

Second edition
1992-11-01

Corrected and reprinted
1993-05-15

Quantities and units — **Part 5:** Electricity and magnetism

Grandeurs et unités —

Partie 5: Électricité et magnétisme



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 31-5 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors*.

This second edition cancels and replaces the first edition (ISO 31-5:1979). The major technical changes from the first edition are the following:

- the decision by the International Committee for Weights and Measures (Comité International des Poids et Mesures, CIPM) in 1980 concerning the status of supplementary units has been incorporated;
- a number of new items have been added, e.g. active energy.

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.

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 and B of this part of ISO 31 are for information only.

Introduction

0.1 Arrangement of the tables

The tables of quantities and units in ISO 31 are arranged so that the quantities are presented on the left-hand pages and the units on the corresponding right-hand pages.

All units between two full lines belong to the quantities between the corresponding full lines on the left-hand pages.

Where the numbering of an item has been changed in the revision of a part of ISO 31, or in the revision of IEC 27-1, the number in the preceding edition is shown in parentheses on the left-hand page under the new number for the quantity; a dash is used to indicate that the item in question did not appear in the preceding edition.

0.2 Tables of quantities

The most important quantities within the field of this document are given together with their symbols and, in most cases, definitions. These definitions are given merely for identification; they are not intended to be complete.

The vectorial character of some quantities is pointed out, especially when this is needed for the definitions, but no attempt is made to be complete or consistent.

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 (sloping) letter exist (for example as with ϑ , θ ; φ , ϕ ; g , g) only one of these is given. This does not mean that the other is not equally acceptable. In general it is recommended that such variants should not be given different meanings. A symbol within parentheses implies that it is a "reserve symbol", to be used when, in a particular context, the main symbol is in use with a different meaning.

0.3 Tables of units

0.3.1 General

Units for the corresponding quantities are given together with the international symbols and the definitions. For further information, see ISO 31-0.

The units are arranged in the following way:

- a) The names of the SI units are given in large print (larger than text size). The SI units have been adopted by the General Conference on Weights and Measures (Conférence Générale des Poids et Mesures, CGPM).

The SI units and their decimal multiples and sub-multiples are recommended, although the decimal multiples and sub-multiples are not explicitly mentioned.

- b) The names of non-SI units which may be used together with SI units because of their practical importance or because of their use in specialized fields are given in normal print (text size).

These units are separated by a broken line from the SI units for the quantities concerned.

- c) The names of non-SI units which may be used temporarily together with SI units are given in small print (smaller than text size) in the "Conversion factors and remarks" column.
- d) The names of non-SI units which should not be combined with SI units are given only in annexes in some parts of ISO 31. These annexes are informative and not integral parts of the standard. They are arranged in three groups:
- 1) special names of units in the CGS system;
 - 2) names of units based on the foot, pound and second and some other related units;
 - 3) names of other units.

0.3.2 Remark on units for quantities of dimension one

The coherent unit for any quantity of dimension one 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 may be used.

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 has specified that, in the International System of Units, the radian, rad, and the steradian, 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 may be omitted, or they may be used in expressions for derived units to facilitate distinction between quantities of different nature but having the same dimension.

0.4 Numerical statements

All numbers in the "Definition" column are exact.

When numbers in the "Conversion factors and remarks" column are exact, the word "exactly" is added in parentheses after the number.

0.5 Special remarks

The items given in this part of ISO 31 are in general conformity with the recommendations in IEC 27-1. If a name or a symbol in a table is not in accordance with what is given by the IEC, this is indicated in the "Conversion factors and remarks" column.

0.5.1 Equations and quantities

For electricity and magnetism, different systems of equations have been developed depending on the number and the particular choice of base quantities on which the system of equations is based. For the purpose of explaining this document, only the following systems need be mentioned.

0.5.1.1 System of equations with four base quantities

In the four-dimensional system of equations with four base quantities, one electrical quantity is included in the base set. The base quantities are chosen to be: length, time, mass and electric current. In this system the permittivity and the permeability appear as dimensional quantities in the relevant equations.

The equations are always written in a form which is called rationalized, because in the equations factors 4π and 2π appear only in cases involving spherical or circular symmetry respectively.

This rationalized system of equations based on four base quantities is the one most commonly used in practical calculations in the physical sciences and in technology. Therefore, it has been strictly adhered to in this part of ISO 31.

0.5.1.2 System of equations with three base quantities

This system is presented for information in annexes A and B, which are informative and not integral parts of this part of ISO 31. It is not given in IEC 27-1.

0.5.2 Units

The quantities which belong to the four-dimensional system (see 0.5.1.1) should be expressed in units of the sub-system of the International System of Units with the four base units:

metre, kilogram, second and ampere.

0.5.3 Alternating-current technology

For quantities used in electrotechnology which vary with time, and for complex representation of quantities, the IEC has standardized the use of upper-case and lower-case letters and additional marks to such letters. These are given in IEC 27-1.

Thus, for example, the sinusoidal variation with time of an electric current (item 5-1) can be expressed in real representation as

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

where $(\omega t - \varphi)$ is the phase, i the instantaneous value of the current, $\hat{i}$ its peak value, and I its root-mean-square (r.m.s.) value.

Quantities and units —

Part 5: Electricity and magnetism

1 Scope

This part of ISO 31 gives names and symbols for quantities and units of electricity and magnetism. Where appropriate, conversion factors are also given.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 31. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this

part of ISO 31 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 27-1:1992, *Letter symbols to be used in electrical technology — Part 1: General*.

3 Names and symbols

The names and symbols for quantities and units of electricity and magnetism are given on the following pages.

ELECTRICITY AND MAGNETISM					Quantities
Item No.	Number in IEC 27-1:1992	Quantity	Symbol	Definition	Remarks
5-1	67	electric current	I		Electric current is one of the base quantities on which the SI is based. For alternating current see the introduction, subclause 0.5.3.
5-2	52	electric charge, quantity of electricity	Q	Integral of electric current over time	For alternating current see the introduction, subclause 0.5.3.
5-3	54	volumic charge, volume density of charge, charge density	$\varrho, (\eta)$	Charge divided by volume	IEC does not give "charge density" or "volumic charge".
5-4	53	areic charge, surface density of charge	σ	Charge divided by surface area	IEC does not give "areic charge".
5-5	55	electric field strength	E	Force, exerted by electric field on an electric point charge, divided by the electric charge	For alternating current see the introduction, subclause 0.5.3.

Units					ELECTRICITY AND MAGNETISM				
Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks					
5-1.a	ampere	A	The ampere is that constant electric 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 2×10^{-7} newton per metre of length						
5-2.a	coulomb	C	$1 \text{ C} = 1 \text{ A} \cdot \text{s}$	The unit ampere hour, $1 \text{ A} \cdot \text{h} = 3,6 \text{ kC}$ (exactly), is used for storage batteries.					
5-3.a	coulomb per cubic metre	C/m^3							
5-4.a	coulomb per square metre	C/m^2							
5-5.a	volt per metre	V/m	$1 \text{ V}/\text{m} = 1 \text{ N}/\text{C}$						

ELECTRICITY AND MAGNETISM (<i>continued</i>)					Quantities
Item No.	Number in IEC 27-1:1992	Quantity	Symbol	Definition	Remarks
5-6.1	56	electric potential	V, φ	For electrostatic fields, a scalar quantity, the gradient of which, with reversed sign, is equal to the electric field strength. $\mathbf{E} = - \text{grad } V$	IEC gives φ as reserve symbol.
5-6.2	57	potential difference, tension	$U, (V)$	For electrostatic fields, the potential difference between point 1 and point 2 is the line integral from 1 to 2 of the electric field strength. $U = \varphi_1 - \varphi_2 = \int_{r_1}^{r_2} \mathbf{E} \cdot d\mathbf{r}$	IEC also gives "voltage". For alternating current see the introduction, subclause 0.5.3.
5-6.3	58	electromotive force	E	Energy supplied by a source divided by the electric charge transported through the source	
5-7	60	electric flux density	D	Vector quantity, the divergence of which is equal to the volumic charge. $\text{div } \mathbf{D} = \rho$	See 5-10.1. Displacement is also used.
5-8	59	electric flux	Ψ	Across a surface element, the scalar product of the electric flux density and the surface element. $\Psi = \int \mathbf{D} \cdot \mathbf{e}_n dA$	Flux of displacement is also used.
5-9	61	capacitance	C	Charge divided by potential difference	
5-10.1	62	permittivity	ε	$\mathbf{D} = \varepsilon \mathbf{E}$	IEC also gives "absolute permittivity, (capacitivity)" for ε .
5-10.2	206	electric constant, permittivity of vacuum	ε_0		$\varepsilon_0 = 1/(\mu_0 c_0^2) =$ $\frac{10^7}{4\pi \times 299\,792\,458^2} \text{ F/m}$ (exactly) = $8,854\,188 \times 10^{-12} \text{ F/m}$