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

Reference number
ISO 31-5:1992(E)

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.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

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 (Conference 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 (1). When the value of such a quantity is expressed, the unit 1 is generally not written out explicitly. Prefixes shall not be used to form multiples or sub-multiples of this unit. Instead of prefixes, powers of 10 may be used.

EXAMPLES

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

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

Considering that plane angle is generally expressed as the ratio between two lengths, and solid angle as the ratio between an area and the square of a length, the CIPM specified in 1980 that, in the International System of Units, the radian and steradian are dimensionless derived units. This implies that the quantities plane angle and solid angle are considered as dimensionless derived quantities. The units radian and steradian 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	ϱ, (η)	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	$1 \text{ V/m} = 1 \text{ N/C}$	

ELECTRICITY AND MAGNETISM (*continued*) — 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. $\boldsymbol{E} = -\ \mathbf{grad}\ V$	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. $U = \varphi_1 - \varphi_2 = \int_{\boldsymbol{r}_1}^{\boldsymbol{r}_2} \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{r}$	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. div $\boldsymbol{D} = \varrho$	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. $\Psi = \int \boldsymbol{D} \cdot \boldsymbol{e}_\mathrm{n}\, \mathrm{d}A$	Flux of displacement is also used.
5-9	61	capacitance	C	Charge divided by potential difference	
5-10.1	62	permittivity	ε	$\boldsymbol{D} = \varepsilon \boldsymbol{E}$	IEC also gives "absolute permittivity, (capacitivity)" for ε.
5-10.2	206	electric constant, permittivity of vacuum	ε_0		$\varepsilon_0 = 1/(\mu_0 c_0^2) = \dfrac{10^7}{4\pi \times 299\ 792\ 458^2}$ F/m (exactly) = $8{,}854\ 188 \times 10^{-12}$ F/m

Units ELECTRICITY AND MAGNETISM (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
5-6.a	volt	V	1 V = 1 W/A	
5-7.a	coulomb per square metre	C/m^2		
5-8.a	coulomb	C		
5-9.a	farad	F	1 F = 1 C/V	
5-10.a	farad per metre	F/m		

ELECTRICITY AND MAGNETISM (*continued*) Quantities

Item No.	Number in IEC 27-1:1992	Quantity	Symbol	Definition	Remarks
5-11	63	relative permittivity	ε_r	$\varepsilon_r = \varepsilon / \varepsilon_0$	IEC also gives "(relative capacitivity)".
5-12	63a	electric susceptibility	χ, χ_e	$\chi = \varepsilon_r - 1$	
5-13	65	electric polarization	P	$\boldsymbol{P} = \boldsymbol{D} - \varepsilon_0 \boldsymbol{E}$	IEC gives D_i as reserve symbol.
5-14	66	electric dipole moment	p, (p_e)	Vector quantity, the vector product of which with the electric field strength of a homogenous field is equal to the torque. $\boldsymbol{p} \times \boldsymbol{E} = \boldsymbol{T}$	
5-15	68	areic electric current, electric current density	J, (S)	Vector quantity, the integral of which over a given surface is equal to the electric current flowing through that surface. $I = \int \boldsymbol{J} \cdot \boldsymbol{e}_n \, dA$	j is also used. IEC does not give "areic electric current".
5-16	69	lineic electric current, linear electric current density	A, (α)	Electric current in a conducting sheet divided by the width of the sheet	IEC does not give "lineic electric current".
5-17	70	magnetic field strength	H	Vector quantity, the rotation (curl) of which is equal to the sum of the electric current density and the time derivative of the electric flux density. $\mathbf{rot}\ \boldsymbol{H} = \boldsymbol{J} + \frac{\partial \boldsymbol{D}}{\partial t}$	

Units				ELECTRICITY AND MAGNETISM (*continued*)
Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
5-11.a	one	1		See the introduction, subclause 0.3.2.
5-12.a	one	1		See the introduction, subclause 0.3.2.
5-13.a	coulomb per square metre	C/m^2		
5-14.a	coulomb metre	$C \cdot m$		
5-15.a	ampere per square metre	A/m^2		
5-16.a	ampere per metre	A/m		
5-17.a	ampere per metre	A/m		

ELECTRICITY AND MAGNETISM (*continued*) Quantities

Item No.	Number in IEC 27-1:1992	Quantity	Symbol	Definition	Remarks
5-18.1	71	magnetic potential difference	U_m, (U)	On a given path, the magnetic potential difference between point 1 and point 2 is the line integral from 1 to 2 of the magnetic field strength along that path. $U_m = \int_{\boldsymbol{r}_1}^{\boldsymbol{r}_2} \boldsymbol{H} \cdot d\boldsymbol{r}$	IEC gives U as symbol and $\mathscr{U}$ as reserve symbol.
5-18.2	72	magnetomotive force	F, F_m	$F = \oint \boldsymbol{H} \cdot d\boldsymbol{r}$	IEC gives $\mathscr{F}$ as reserve symbol.
5-18.3	72a	current linkage	Θ	Net electric conduction current through a closed loop	When Θ results from N equal electric currents I, $\Theta = NI$.
5-19	73	magnetic flux density, magnetic induction	B	Vector quantity such that the force exerted on an element of electric current is equal to the vector product of this element and the magnetic flux density. $\boldsymbol{F} = I \Delta \boldsymbol{s} \times \boldsymbol{B}$	
5-20	74	magnetic flux	Φ	Across a surface element, the scalar product of the magnetic flux density and the surface element. $\Phi = \int \boldsymbol{B} \cdot \boldsymbol{e}_n \, dA$	
5-21	75	magnetic vector potential	A	Vector quantity, the rotation (curl) of which is equal to the magnetic flux density. $\boldsymbol{B} = \mathbf{rot}\ \boldsymbol{A}$	

Units				ELECTRICITY AND MAGNETISM (*continued*)
Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
5-18.a	ampere	A		
5-19.a	tesla	T	$1\ T = 1\ N/(A \cdot m)$	$1\ T = 1\ Wb/m^2 = 1\ V \cdot s/m^2$
5-20.a	weber	Wb	$1\ Wb = 1\ V \cdot s$	
5-21.a	weber per metre	Wb/m		

ELECTRICITY AND MAGNETISM (*continued*) Quantities

Item No.	Number in IEC 27-1:1992	Quantity	Symbol	Definition	Remarks
5-22.1	76	self inductance	L	For a thin conducting loop, the magnetic flux through the loop, caused by an electric current in the loop, divided by that current	
5-22.2	77	mutual inductance	M, L_{mn}	For two thin conducting loops (m and n), the magnetic flux through one loop, due to an electric current in the other loop, divided by that current	
5-23.1	78	coupling factor	k, ($\varkappa$)	For inductive coupling $k = \lvert L_{mn}\rvert / \sqrt{L_m L_n}$	
5-23.2	79	leakage factor	σ	$\sigma = 1 - k^2$	
5-24.1	80	permeability	μ	$\boldsymbol{B} = \mu \boldsymbol{H}$	IEC also gives "absolute permeability" for μ.
5-24.2	207	magnetic constant, permeability of vacuum	μ_0		$\mu_0 = 4\pi \cdot 10^{-7}$ H/m (exactly) = $1{,}256\ 637 \times 10^{-6}$ H/m
5-25	81	relative permeability	μ_r	$\mu_r = \mu/\mu_0$	
5-26	82	magnetic susceptibility	$\varkappa$, (χ_m)	$\varkappa = \mu_r - 1$	
5-27	83	magnetic moment, electromagnetic moment	$\boldsymbol{m}$	Vector quantity, the vector product of which with the magnetic flux density of a homogeneous field is equal to the torque. $\boldsymbol{m} \times \boldsymbol{B} = \boldsymbol{T}$	IEC also gives "magnetic area moment". IEC also defines the quantity magnetic dipole moment, $\boldsymbol{j} = \mu_0 \boldsymbol{m}$.
5-28	84	magnetization	$\boldsymbol{M}$, ($\boldsymbol{H}_i$)	$\boldsymbol{M} = (\boldsymbol{B}/\mu_0) - \boldsymbol{H}$	IEC gives $\boldsymbol{H}_i$, $\boldsymbol{M}$.
5-29	85	magnetic polarization	$\boldsymbol{J}$, ($\boldsymbol{B}_i$)	$\boldsymbol{J} = \boldsymbol{B} - \mu_0 \boldsymbol{H}$	IEC gives $\boldsymbol{B}_i$, $\boldsymbol{J}$.

Units ELECTRICITY AND MAGNETISM (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
5-22.a	henry	H	1 H = 1 Wb/A	1 H = 1 V · s/A
5-23.a	one	1		See the introduction, subclause 0.3.2.
5-24.a	henry per metre	H/m		
5-25.a	one	1		See the introduction, subclause 0.3.2.
5-26.a	one	1		See the introduction, subclause 0.3.2.
5-27.a	ampere square metre	$A \cdot m^2$		The quantity magnetic dipole moment has the unit Wb · m.
5-28.a	ampere per metre	A/m		
5-29.a	tesla	T		

ELECTRICITY AND MAGNETISM (*continued*)					Quantities
Item No.	**Number in IEC 27-1:1992**	**Quantity**	**Symbol**	**Definition**	**Remarks**
5-30	42	volumic electromagnetic energy, electromagnetic energy density	w	Electromagnetic field energy divided by volume. $w = \frac{1}{2}(\boldsymbol{E} \cdot \boldsymbol{D} + \boldsymbol{B} \cdot \boldsymbol{H})$	
5-31	102	Poynting vector	S	Vector product of electric field strength and magnetic field strength. $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$	The magnitude of the Poynting vector is the power flux density.
5-32.1 (—)	25 (*23*)	phase velocity of electromagnetic waves, phase speed of electromagnetic waves	c		
5-32.2 (*5-32.1*)	201	velocity of electromagnetic waves in vacuum, speed of electromagnetic waves in vacuum	c, c_0		$c_0 = 1/\sqrt{\varepsilon_0 \mu_0}$ = 299 792 458 m/s (exactly) If the symbol c is used for the speed in a medium, c_0 should be used for the speed in vacuum. IEC gives only c_0.
5-33	87	resistance (to direct current)	R	Electric potential difference divided by current when there is no electromotive force in the conductor	For alternating current, see 5-44.3.
5-34	89	conductance (for direct current)	G	$G = 1/R$	For alternating current, see 5-45.3.
5-35 (—)	43	power (for direct current)	P	$P = UI$	For alternating current, see 5-49.
5-36 (*5-35.1*)	88	resistivity	ϱ	$\boldsymbol{E} = \varrho \boldsymbol{J}$	
5-37 (*5-36.1*)	90	conductivity	γ, σ	$\gamma = 1/\varrho$	$\varkappa$ is used in electrochemistry.

Units ELECTRICITY AND MAGNETISM (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
5-30.a	joule per cubic metre	J/m^3		
5-31.a	watt per square metre	W/m^2		
5-32.a	metre per second	m/s		
5-33.a	ohm	Ω	1 Ω = 1 V/A	
5-34.a	siemens	S	$1\ S = 1\ \Omega^{-1}$	
5-35.a	watt	W	1 W = 1 V · A	
5-36.a	ohm metre	Ω · m		
5-37.a	siemens per metre	S/m		

ELECTRICITY AND MAGNETISM (*continued*)					Quantities
Item No.	**Number in IEC 27-1:1992**	**Quantity**	**Symbol**	**Definition**	**Remarks**
5-38 (*5-37.1*)	91	reluctance	R, R_m	Magnetic potential difference divided by magnetic flux	IEC gives $\mathscr{R}$ as a reserve symbol.
5-39 (*5-38.1*)	92	permeance	Λ, (P)	$\Lambda = 1/R_m$	
5-40.1 (*5-39.1*)	104	number of turns in a winding	N		
5-40.2 (*5-39.2*)	105	number of phases	m		
5-41.1 (—)	18 (*16*)	frequency	f, ν	Number of cycles divided by time	IEC gives ν as reserve symbol.
5-41.2 (—)	19 (*17*)	rotational frequency	n	Number of revolutions divided by time	
5-42 (—)	21 (*19*)	angular frequency, pulsatance	ω	$\omega = 2\pi f$	

Units				ELECTRICITY AND MAGNETISM (*continued*)
Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
5-38.a	reciprocal henry, henry to the power minus one	H^{-1}		
5-39.a	henry	H		
5-40.a	one	1		See the introduction, subclause 0.3.2.
5-41.a	hertz	Hz	$1\ Hz = 1\ s^{-1}$	1 Hz is the frequency of a periodic phenomenon of which the period is 1 s.
5-41.b	reciprocal second, second to the power minus one	s^{-1}		The designations "revolutions per minute" (r/min) and "revolutions per second" (r/s) are widely used as units for rotational frequency in specifications on rotating machinery. Language-dependent abbreviations such as the English rev/min and rpm (revolutions per minute) and rev/s and rps (revolutions per second), and the French tr/min (tours par minute) and tr/s (tours par seconde), are not recommended.[1)]
5-42.a	radian per second	rad/s		See the introduction, subclause 0.3.2.
5-42.b	reciprocal second, second to the power minus one	s^{-1}		

1) See also IEC 27-1.

ELECTRICITY AND MAGNETISM (*continued*) Quantities

Item No.	Number in IEC 27-1:1992	Quantity	Symbol	Definition	Remarks
5-43 (*5-40.1*)	103	phase difference	φ	When $u = \hat{u} \cos \omega t$ and $i = \hat{i} \cos(\omega t - \varphi)$, then φ is the phase difference	See also the introduction, subclause 0.3.2. $(\omega t - \varphi)$ is called the phase of i. IEC gives ϑ as reserve symbol. Remark on 5-43 to 5-52: see also introduction, subclause 0.5.3.
5-44.1 (*5-41.1*)	93	impedance, (complex impedance)	Z	The complex representation of potential difference divided by the complex representation of current	$Z = \|Z\| e^{j\varphi} = R + jX$
5-44.2 (*5-41.2*)	93	modulus of impedance, (impedance)	$\|Z\|$		$\|Z\| = \sqrt{R^2 + X^2}$ When there is no risk of confusion the name impedance can be used for the quantity 5-44.2.
5-44.3 (*5-41.4*)	87	resistance (to alternating current)	R	Real part of impedance	
5-44.4 (*5-41.3*)	94	reactance	X	Imaginary part of impedance	$X = \omega L - \frac{1}{\omega C}$ for an inductive reactance and a capacitive reactance in series.

Units ELECTRICITY AND MAGNETISM (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
5-43.a	radian	rad		See the introduction, subclause 0.3.2.
5-43.b	one	1		
5-44.a	ohm	Ω		

ELECTRICITY AND MAGNETISM (*concluded*)					Quantities
Item No.	**Number in IEC 27-1:1992**	**Quantity**	**Symbol**	**Definition**	**Remarks**
5-45.1 (*5-43.1*)	97	admittance, (complex admittance)	Y	$Y = 1/Z$	$Y = \|Y\|e^{-j\varphi} = G + jB = \frac{R - jX}{\|Z\|^2}$
5-45.2 (*5-43.2*)	97	modulus of admittance, (admittance)	$\|Y\|$		$\|Y\| = \sqrt{G^2 + B^2}$ When there is no risk of confusion, the name admittance can be used for the quantity 5-45.2.
5-45.3 (*5-43.4*)	89	conductance (for alternating current)	G	Real part of admittance	
5-45.4 (*5-43.3*)	98	susceptance	B	Imaginary part of admittance	
5-46 (*5-42.1*)	95	quality factor	Q	For non-radiating systems, if $Z = R + jX$, then $Q = \|X\|/R$	
5-47 (—)	101b	loss factor	d	$d = 1/Q$	
5-48 (—)	96	loss angle	δ	$\delta = \arctan d$	
5-49 (*5-44.1*)	99	active power	P	$P = \frac{1}{T}\int_0^T ui \, dt$	$p = ui$ is the instantaneous power.
5-50.1 (—)	100	apparent power	S, (P_S)	$S = UI$	When $u = \hat{u} \cos \omega t = \sqrt{2}\, U \cos \omega t$ and $i = \hat{i} \cos(\omega t - \varphi) = \sqrt{2}\, I \cos(\omega t - \varphi)$, then $P = UI \cos \varphi$ $Q = UI \sin \varphi$ $\lambda = \cos \varphi$
5-50.2 (—)	101	reactive power	Q, P_Q	$Q^2 = S^2 - P^2$	
5-51 (—)	101a	power factor	λ	$\lambda = P/S$	
5-52 (—)	101c	active energy	W, (W_P)	$W = \int ui \, dt$	

Units ELECTRICITY AND MAGNETISM (*concluded*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
5-45.a	siemens	S		
5-46.a	one	1		See the introduction, subclause 0.3.2.
5-47.a	one	1		See the introduction, subclause 0.3.2.
5-48.a	radian	rad		See the introduction, subclause 0.3.2.
5-49.a	watt	W		
5-50.a	volt ampere	V · A		IEC has adopted the name and symbol var for the volt ampere as unit for reactive power.
5-51.a	one	1		See the introduction, subclause 0.3.2.
5-52.a	joule	J		
5-52.b	watt hour	W · h		1 kW · h = 3,6 MJ

(Blank page)

Annex A
(informative)

Three-dimensional equations and quantities

Different three-dimensional systems of equations have been developed for electric and magnetic quantities based on the three base quantities length, time and mass. Only the so-called Gaussian or "symmetric" system of equations is still used. Further details are given for information in the IUPAP-SUN Publication, 1987.[1)]

Physical quantities defined through this system of equations in terms of the three base quantities are called Gaussian quantities.

The symbol chosen for each Gaussian quantity is that of the corresponding quantity in the system with four base quantities, with the subscript s (symmetric) added.

The Gaussian system of equations defines the electric charge as a derived physical quantity, on the basis of Coulomb's law for the force between two Gaussian electric charges, by taking the permittivity to be a quantity of dimension one equal to unity in vacuum. The speed of light appears explicitly in some of the equations combining electric and magnetic quantities in such a way that the permeability turns out to be a quantity of dimension one equal to unity in vacuum. The Gaussian system of equations is written in non-rationalized form.

The relation of the Gaussian quantity to the corresponding four-dimensional quantity is always given in the "Conversion factors and remarks" column on the left-hand page.

Some of the essential equations of the Gaussian system are given in annex B.

The Gaussian quantities which belong to the three-dimensional Gaussian system are commonly measured in units of the Gaussian CGS system with the three base units centimetre, gram and second.[2)]

1) IUPAP-SUN stands for International Union of Pure and Applied Physics, commission for Symbols, Units and Nomenclature.

2) IEC does not give this system.

GAUSSIAN SYSTEM Quantities

Item No.	Quantity	Symbol	Definition	Remarks
5-1$_s$	Gaussian electric current	I_s	Gaussian electric charge crossing a surface divided by time	$I_s = I/(4\pi\varepsilon_0)^{1/2}$ $\varepsilon_0 = 10^{11}\zeta^{-2}(4\pi)^{-1}$ F/m For ζ, see 5-1.a$_s$.
5-2$_s$	Gaussian electric charge, Gaussian quantity of electricity	Q_s	The Gaussian electric charge is defined by $F = Q_{s1}Q_{s2}/r^2$ where F is the force in vacuum and r is the distance between two points with Gaussian electric charges Q_{s1} and Q_{s2}	$Q_s = Q/(4\pi\varepsilon_0)^{1/2}$
5-5$_s$	Gaussian electric field strength	E_s	Force, exerted by an electric field on an electric charge, divided by the Gaussian electric charge	$E_s = E/(4\pi\varepsilon_0)^{1/2}$
5-6.1$_s$	Gaussian electric potential	V_s, φ_s	For electrostatic fields, a scalar quantity, the gradient of which, with reversed sign, is equal to the Gaussian electric field strength	$V_s = V/(4\pi\varepsilon_0)^{1/2}$
5-7$_s$	Gaussian electric flux density	D_s	Vector quantity, the divergence of which is equal to 4π times the Gaussian charge density. div $\boldsymbol{D}_s = 4\pi\varrho_s$	This quantity is sometimes called electric induction. $D_s = D(4\pi/\varepsilon_0)^{1/2}$
5-9$_s$	Gaussian capacitance	C_s	Gaussian charge divided by Gaussian potential difference	$C_s = C/4\pi\varepsilon_0$
5-11$_s$	Gaussian permittivity	ε_s	Gaussian electric flux density divided by the Gaussian electric field strength	The Gaussian permittivity is identical with the relative permittivity. $\varepsilon_s = \varepsilon_r = \varepsilon/\varepsilon_0$