INTERNATIONAL STANDARD

ISO 31-6

Third edition
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Quantities and units —

Part 6:
Light and related electromagnetic radiations

Grandeurs et unités —

Partie 6: Lumière et rayonnements électromagnétiques connexes

Reference number
ISO 31-6:1992(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 31-6 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors*.

This third edition cancels and replaces the second edition (ISO 31-6:1980). The major technical changes from the second 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;

— the unit ångström, Å, in use temporarily, has been transferred to the "Conversion factors and remarks" column;

— a number of new items have been added, e.g. photonic quantities and units.

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.

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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*

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, 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

0.5.1 Quantities

This part of ISO 31 contains a selection of quantities pertaining to light and other electromagnetic radiation. "Radiant" quantities relating to radiation in general may be useful for the whole range of electromagnetic radiations, whereas "luminous" quantities pertain only to visible light.

In several cases, the same symbol is used for a trio of corresponding radiant, luminous and photonic quantities with the understanding that subscripts e for energetic, v for visible and p for photonic will be added whenever confusion between these quantities might otherwise occur.

For ionizing radiations, however, see ISO 31-10.

Several quantities in this part of ISO 31 are spectral concentrations expressed in terms of wavelength. The definition is given explicitly in 6.9 and the relation to 6.8 is shown in the remarks column. Other spectral concentrations are indicated by equations in the "Remarks" column. The subscript λ is used as part of the symbol to indicate that the quantity has the dimension of a derivative with respect to λ. Spectral concentrations expressed in terms of frequency or repetency are defined and denoted similarly, the subscript λ being replaced by ν or σ respectively. Spectral concentrations are also called distribution functions, for example wavelength distribution function, frequency distribution function. The name of a quantity which is a spectral concentration may be shortened by replacing the words "spectral concentration of" by the adjective "spectral", for example spectral concentration of radiant energy density may be called spectral radiant energy density.

The adjective "spectral" is also used to designate quantities which are functions of wavelength (or frequency or repetency), but which are not spectral concentrations, for example spectral emissivity (see 6-21.2). The functional dependence is usually indicated by including λ (or ν or σ) in parentheses as part of the symbol, for example $\varepsilon(\lambda)$.

0.5.2 Units

In photometry and radiometry, the unit steradian is used for convenience.

Quantities and units —

Part 6:
Light and related electromagnetic radiations

1 Scope

This part of ISO 31 gives names and symbols for quantities and units of light and related electromagnetic radiations. 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.

ISO 31-8:1992, *Quantities and units — Part 8: Physical chemistry and molecular physics.*

3 Names and symbols

The names and symbols for quantities and units of light and related electromagnetic radiations are given on the following pages.

LIGHT AND RELATED ELECTROMAGNETIC RADIATIONS — Quantities

Item No.	Quantity	Symbol	Definition	Remarks
6-1	frequency	f, ν	Number of cycles divided by time	
6-2	angular frequency	ω	$\omega = 2\pi\nu$	
6-3	wavelength	λ	Distance in the direction of propagation of a periodic wave between two successive points where at a given time the phase is the same	The wavelength in a medium is equal to the wavelength in vacuum divided by the refractive index of the medium (see 6-44).
6-4	repentency, wavenumber	σ	$\sigma = 1/\lambda$	In molecular spectroscopy $\tilde{\nu}$ is used for ν/c. The vector quantities $\boldsymbol{\sigma}$ and $\boldsymbol{k}$ corresponding to repetency and angular repetency are called wave vector and propagation vector respectively.
6-5 (*6-4.2*)	angular repetency, angular wavenumber	k	$k = 2\pi\sigma$	
6-6 (*6-5.1*)	velocity (speed) of electromagnetic waves in vacuum	c, c_0		c = 299 792 458 m/s (exactly) When it is necessary to make a distinction between phase velocity in a medium and phase velocity in vacuum, c is used for the former and c_0 for the latter.
6-7 (*6-6.1*)	radiant energy	Q, W, (U, Q_e)	Energy emitted, transferred or received as radiation	

Units — LIGHT AND RELATED ELECTROMAGNETIC RADIATIONS

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
6-1.a	hertz	Hz	1 Hz = 1 s^{-1}	
6-2.a	radian per second	rad/s		
6.2.b	reciprocal second, second to the power minus one	s^{-1}		
6-3.a	metre	m		ångström (Å), 1 Å = 10^{-10} m
6-4.a	reciprocal metre, metre to the power minus one	m^{-1}		The multiple cm^{-1} $\left(= 100\ m^{-1}\right)$ is often used.
6-5.a	radian per metre	rad/m		
6-5.b	reciprocal metre, metre to the power minus one	m^{-1}		
6-6.a	metre per second	m/s		
6-7.a	joule	J	1 J = 1 N · m	

LIGHT AND RELATED ELECTROMAGNETIC RADIATIONS (*continued*) — Quantities

Item No.	Quantity	Symbol	Definition	Remarks
6-8 (*6-7.1*)	radiant energy density	w, (u)	Radiant energy in an element of volume, divided by that element	For non-polarized black-body (full) radiation $w_\lambda = 8\pi hc \cdot f(\lambda, T)$ and $w = \frac{4\sigma}{c} T^4$. The Planck constant h is equal to $h = (6{,}626\ 075\ 5 \pm 0{,}000\ 004\ 0) \times 10^{-34}$ J · s [1]. For $f(\lambda, T)$, see 6-19 and 6-20, and for σ, see 6-18. $w = \int w_\lambda \, d\lambda$ See also the introduction, subclause 0.5.1.
6-9 (*6-8.1*)	spectral concentration of radiant energy density (in terms of wavelength), spectral radiant energy density (in terms of wavelength)	w_λ	Radiant energy density in an infinitesimal wavelength interval, divided by the range of that interval	
6-10 (*6-9.1*)	radiant power, radiant energy flux	P, Φ, (Φ_e)	Power emitted, transferred or received as radiation	$\Phi = \int \Phi_\lambda \, d\lambda$
6-11 (—)	radiant energy fluence	Ψ	At a given point in space, the radiant energy incident on a small sphere divided by the cross-sectional area of that sphere	
6-12 (*6-10.1*)	radiant energy fluence rate	φ, ψ	$\varphi = \frac{d\Psi}{dt}$	$\varphi = \int \varphi_\lambda \, d\lambda$ In an isotropic homogeneous radiation field, φ/c is the energy density, and the irradiance of a surface is $\varphi/4$
6-13 (*6-11.1*)	radiant intensity	I, (I_e)	In a given direction from a source, the radiant energy flux leaving the source, or an element of the source, in an element of solid angle containing the given direction, divided by that element of solid angle	$I = \int I_\lambda \, d\lambda$

1) CODATA Bulletin 63 (1986).

Units			LIGHT AND RELATED ELECTROMAGNETIC RADIATIONS (*continued*)	
Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
6-8.a	joule per cubic metre	J/m^3		
6-9.a	joule per metre to the fourth power	J/m^4		
6-10.a	watt	W	1 W = 1 J/s	
6-11.a	joule per square metre	J/m^2		
6-12.a	watt per square metre	W/m^2		
6-13.a	watt per steradian	W/sr		For the steradian, see the introduction, subclause 0.3.2.