INTERNATIONAL STANDARD

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AMENDMENT 1
1998-12-15

Quantities and units —

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 12: Characteristic numbers
Part 13: Solid state physics

AMENDMENT 1

Grandeurs et unités —

Partie 1: Espace et temps
Partie 2: Phénomènes périodiques et connexes
Partie 3: Mécanique
Partie 4: Chaleur
Partie 5: Électricité et magnétisme
Partie 6: Lumière et rayonnements électromagnétiques connexes
Partie 7: Acoustique
Partie 8: Chimie physique et physique moléculaire
Partie 9: Physique atomique et nucléaire
Partie 10: Réactions nucléaires et rayonnements ionisants
Partie 12: Nombres caractéristiques
Partie 13: Physique de l'état solide

AMENDEMENT 1

Reference number
ISO 31 (parts 1 to 10, 12 and 13):1992/Amd.1:1998(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.

Amendment 1 to parts 1 to 10, 12 and 13 of International Standard ISO 31:1992 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors.*

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ISO 31-10:1992/Amd.1:1998(E)
ISO 31-12:1992/Amd.1:1998(E)
ISO 31-13:1992/Amd.1:1998(E)

Quantities and units —

Part 1: Space and time
Part 2: Periodic and related phenomena
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Part 12: Characteristic numbers
Part 13: Solid state physics

AMENDMENT 1

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Replace subclause 0.3.2 with the following text:

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.

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INTERNATIONAL STANDARD

ISO 31-12

Third edition
1992-09-01

Quantities and units —

Part 12: Characteristic numbers

Grandeurs et unités —

Partie 12: Nombres caractéristiques

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

This third edition cancels and replaces the second edition (ISO 31-12:1981). 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 title has been changed.

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
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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 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.

0.2 Remarks

0.2.1 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 submultiples 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.

0.2.2 Special remarks

This part of ISO 31 contains a selection of characteristic numbers used for the description of transport phenomena.

Each recommended symbol for such a characteristic number consists of two letters. When such a symbol appears as a factor in a product, it is recommended that it be separated from the other symbols by a space, by a multiplication sign or by parentheses.

The unit of all of the parameters of dimension one is the number one (1). This unit is not explicitly mentioned in the tables in this part of ISO 31.

Quantities and units —

Part 12:
Characteristic numbers

1 Scope

This part of ISO 31 gives names and symbols for characteristic numbers used in the description of transport phenomena.

2 Characteristic numbers: momentum transport

Item No.	Symbol	Name	Definition	Remarks
12-1	Re	Reynolds number	$Re = \frac{\varrho v l}{\eta} = \frac{v l}{\nu}$	
12-2	Eu	Euler number	$Eu = \frac{\Delta p}{\varrho v^2}$	
12-3	Fr	Froude number	$Fr = \frac{v}{\sqrt{lg}}$	Sometimes called Reech number.
12-4	Gr	Grashof number	$Gr = \frac{l^3 g \alpha \Delta T}{\nu^2}$	$-\frac{\Delta \varrho}{\varrho} = \alpha \Delta T$
12-5	We	Weber number	$We = \frac{\varrho v^2 l}{\sigma}$	
12-6	Ma	Mach number	$Ma = \frac{v}{c}$	
12-7	Kn	Knudsen number	$Kn = \frac{\lambda}{l}$	
12-8	Sr	Strouhal number	$Sr = \frac{lf}{v}$	

Symbols used in the definitions in this clause

Symbol	Name of quantity	Reference No. in ISO 31
l	a characteristic length	1-3.1
v	a characteristic speed	1-10
ΔT	a characteristic temperature difference	4-1
Δp	pressure difference	3-15.1
ϱ	volumic mass	3-2
η	dynamic viscosity	3-23
ν	kinematic viscosity: η/ϱ	3-24
σ	surface tension	3-25
g	acceleration of free fall	1-11.2
α	cubic expansion coefficient: $(1/V)\ dV/dT$	4-3.2
λ	mean free path	8-38
f	a characteristic frequency	2-3.1
c	speed of sound	7-14.1

3 Characteristic numbers: transport of heat

Item No.	Symbol	Name	Definition	Remarks
12-9	Fo	Fourier number	$Fo = \frac{\lambda t}{c_p \varrho l^2} = \frac{at}{l^2}$	
12-10	Pe	Péclet number	$Pe = \frac{\varrho c_p v l}{\lambda} = \frac{vl}{a}$	$Pe = Re \cdot Pr$
12-11	Ra	Rayleigh number	$Ra = \frac{l^3 \varrho^2 c_p g \alpha \Delta T}{\eta \lambda} = \frac{l^3 g \alpha \Delta T}{\nu a}$	$Ra = Gr \cdot Pr$
12-12	Nu	Nusselt number	$Nu = \frac{Kl}{\lambda}$	The name Biot number, Bi, is used when the Nusselt number is reserved for convective transport of heat.
12-13	St	Stanton number	$St = \frac{K}{\varrho v c_p}$	$St = Nu/Pe$ Sometimes called the Margoulis number, Ms. $j = St \cdot Pr^{2/3}$ is called the heat transfer factor.

Symbols used in the definitions in this clause

Symbol	Name of quantity	Reference No. in ISO 31
l	a characteristic length	1-3.1
v	a characteristic speed	1-10
t	a characteristic time interval	1-7
ΔT	a characteristic temperature difference	4-1
g	acceleration of free fall	1-11.2
ϱ	volumic mass	3-2
η	dynamic viscosity	3-23
ν	kinematic viscosity: η/ϱ	3-24
c_p	massic heat capacity at constant pressure	4-16.2
α	cubic expansion coefficient: $(1/V)\ dV/dT$	4-3.2
λ	thermal conductivity	4-9
a	thermal diffusivity: $\lambda/\varrho c_p$	4-14
K	coefficient of heat transfer: heat/(time × cross-sectional area × temperature difference)	4-10.1

4 Characteristic numbers: transport of matter in a binary mixture

Item No.	Symbol	Name	Definition	Remarks
12-14	Fo^*	Fourier number for mass transfer	$Fo^* = \frac{Dt}{l^2}$	$Fo^* = Fo/Le$ Compare item 12-9.
12-15	Pe^*	Péclet number for mass transfer	$Pe^* = \frac{vl}{D}$	$Pe^* = Re \cdot Sc = Pe \cdot Le$ Compare item 12-10.
12-16	Gr^*	Grashof number for mass transfer	$Gr^* = \frac{l^3 g \beta \Delta x}{\nu^2}$	Compare item 12-4. $-\frac{\Delta\varrho}{\varrho} = \alpha\Delta T + \beta\Delta x$
12-17	Nu^*	Nusselt number for mass transfer	$Nu^* = \frac{kl}{\varrho D}$	Sometimes called the Sherwood number, Sh. Compare item 12-12.
12-18	St^*	Stanton number for mass transfer	$St^* = \frac{k}{\varrho v}$	$St^* = Nu^*/Pe^*$ Compare item 12-13. $j_m = St^* \cdot Sc^{2/3}$ is called the mass transfer factor.

Symbols used in the definitions in this clause

Symbol	Name of quantity	Reference No. in ISO 31
l	a characteristic length	1-3.1
v	a characteristic speed	1-10
t	a characteristic time interval	1-7
ΔT	a characteristic temperature difference	4-1
Δx	a characteristic difference in mole fraction	8-14.1
g	acceleration of free fall	1-11.2
ϱ	volumic mass	3-2
ν	kinematic viscosity: η/ϱ	3-24
β	$\beta = -(1/\varrho)(\partial\varrho/\partial x)_{T,p}$	—
D	diffusion coefficient	8-39
k	mass transfer coefficient: mass/(time × cross-sectional area × mole-fraction difference)	—
α	cubic expansion coefficient: $(1/V)\ \mathrm{d}V/\mathrm{d}T$	4-3.2

5 Characteristic numbers: constants of matter

Item No.	Symbol	Name	Definitions	Remarks
12-19	Pr	Prandtl number	$Pr = \frac{\eta c_p}{\lambda} = \frac{\nu}{a}$	
12-20	Sc	Schmidt number	$Sc = \frac{\eta}{\varrho D} = \frac{\nu}{D}$	
12-21	Le	Lewis number	$Le = \frac{\lambda}{\varrho c_p D} = \frac{a}{D}$	$Le = Sc/Pr$

Symbols used in the definitions in this clause

Symbol	Name of quantity	Reference No. in ISO 31
ϱ	volumic mass	3-2
η	dynamic viscosity	3-23
ν	kinematic viscosity: η/ϱ	3-24
D	diffusion coefficient	8-39
c_p	massic heat capacity at constant pressure	4-16.2
λ	thermal conductivity	4-9
a	thermal diffusivity: $\lambda/\varrho c_p$	4-14

6 Characteristic numbers: magnetohydrodynamics

Item No.	Symbol	Name	Definition	Remarks
12-22	Rm	magnetic Reynolds number	$Rm = \frac{vl}{1/\mu\sigma} = v\mu\sigma l$	
12-23	Al	Alfvén number	$Al = \frac{v}{B/(\varrho\mu)^{1/2}} = \frac{v}{v_A}$	$v_A = B/(\varrho\mu)^{1/2}$ is called the Alfvén speed.
12-24	Ha	Hartmann number	$Ha = Bl\left(\frac{\sigma}{\varrho\nu}\right)^{1/2}$	
12-25	Co	Cowling number	$Co = \frac{B^2}{\mu\varrho v^2}$	$Co = (v_A/v)^2 = Al^{-2}$ Often called the "second" Cowling number, Co_2. The "first" Cowling number is often defined as $Co_1 = Ha^2/Re = \frac{B^2 l\sigma}{\varrho v} = Co \cdot Rm$

Symbols used in the definitions in this clause

Symbol	Name of quantity	Reference No. in ISO 31
ϱ	volumic mass	3-2
l	a characteristic length	1-3.1
v	a characteristic speed	1-10
ν	kinematic viscosity: η/ϱ	3-24
μ	magnetic permeability	5-24.1
B	magnetic flux density	5-19
σ	electrical conductivity	5-37

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Descriptors: system of units, international system of units, units of measurement, quantities, characteristic numbers, symbols, definitions, conversion of units, conversion factor.

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