INTERNATIONAL STANDARD

ISO 31-4

Second edition
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Quantities and units —

Part 4: Heat

Grandeurs et unités —

Partie 4: Chaleur

Reference number
ISO 31-4:1992(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 31-4 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors*.

This second edition cancels and replaces the first edition (ISO 31-4:1978). 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;

— the International Practical Temperature Scale 1968, IPTS-68, has been replaced by the International Temperature Scale 1990, ITS-90;

— a number of new items have been added.

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*

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, 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 (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.

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Quantities and units —

Part 4:
Heat

1 Scope

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

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 31. At the time of publication, the editions indicated were 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 editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 31-0:1992, *Quantities and units — Part 0: General principles.*

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

Metrologia, **27** (1990), No. 1.

3 Names and symbols

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

HEAT				Quantities
Item No.	**Quantity**	**Symbol**	**Definition**	**Remarks**
4-1	thermodynamic temperature	T, (Θ)		Thermodynamic temperature is one of the base quantities on which the SI is based.
4-2	Celsius temperature	t, ϑ	$t = T - T_0$ where T_0 is defined as being equal to 273,15 K	The thermodynamic temperature T_0 is exactly 0,01 K below the thermodynamic temperature of the triple point of water.

Units				HEAT
Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
4-1.a	kelvin	K	The kelvin, the unit of thermodynamic temperature, is the fraction 1/273,16 of the thermodynamic temperature of the triple point of water	The units of thermodynamic and Celsius temperature interval or difference are identical. The CGPM has recommended that such intervals or differences should be expressed in kelvins (K) or in degrees Celsius (°C). Other names and symbols, such as "degré", "deg", "degree centigrade" or "degree", are deprecated. It should be noted that the symbol °C for the degree Celsius should be preceded by a space (see ISO 31-0:1992, subclause 3.4).
4-2.a	degree Celsius	°C	The degree Celsius is a special name for the kelvin for use in stating values of Celsius temperature	**The International Temperature Scale of 1990 (ITS-90)** For the purpose of practical measurements the International Temperature Scale of 1990 was adopted by the CIPM in 1989, in accordance with Resolution 7 of the 18th CGPM, 1987. It is based on a number of fixed points and interpolation procedures with the help of certain measuring instruments and defines the temperature down to 0,65 K. This scale supersedes the International Practical Temperature Scale of 1968, IPTS-68, (amended edition of 1975) and the 1976 Provisional 0,5 K to 30 K Temperature Scale. The quantities corresponding to thermodynamic temperature and Celsius temperature defined by this scale are indicated respectively by T_{90} and t_{90} (replacing T_{68} and t_{68} defined by IPTS-68), where $t_{90} = T_{90} - T_0$ T_{90} is called the International Kelvin Temperature and t_{90} the International Celsius Temperature. The units of T_{90} and t_{90} are the kelvin, K, and degree Celsius, °C, respectively, as in the case of T and t. For further information see *Metrologia*, **27** (1990), No. 1.

HEAT (*continued*)				Quantities
Item No.	**Quantity**	**Symbol**	**Definition**	**Remarks**
4-3.1	linear expansion coefficient	α_l	$\alpha_l = \frac{1}{l}\frac{\mathrm{d}l}{\mathrm{d}T}$	The quantities 4-3.1 to 4-4 are not completely defined unless the type of change is specified. The subscripts in the symbols may be omitted when there is no risk of confusion. The name pressure coefficient and the symbol β are also used for the quantity 4-3.3.
4-3.2	cubic expansion coefficient	α_V, α, (γ)	$\alpha_V = \frac{1}{V}\frac{\mathrm{d}V}{\mathrm{d}T}$	
4-3.3	relative pressure coefficient	α_p	$\alpha_p = \frac{1}{p}\frac{\mathrm{d}p}{\mathrm{d}T}$	
4-4	pressure coefficient	β	$\beta = \frac{\mathrm{d}p}{\mathrm{d}T}$	
4-5.1	isothermal compressibility	$\varkappa_T$	$\varkappa_T = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_T$	
4-5.2 (—)	isentropic compressibility	$\varkappa_S$	$\varkappa_S = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_S$	
4-6	heat, quantity of heat	Q		The heat transferred in an isothermal phase transformation, formerly called "latent heat", with the symbol L, should be expressed as the change in the appropriate thermodynamic functions, e.g. $T \cdot \Delta S$, where ΔS is the change in entropy, or ΔH, the change in enthalpy.
4-7	heat flow rate	Φ	Rate at which heat crosses a given surface	
4-8	areic heat flow rate, density of heat flow rate	q, φ	Heat flow rate divided by area	
4-9	thermal conductivity	λ, $(\varkappa)$	Areic heat flow rate divided by temperature gradient	
4-10.1	coefficient of heat transfer	K, (k)	Areic heat flow rate divided by temperature difference	In building technology, this quantity is often called thermal transmittance, with the symbol U.
4-10.2 (—)	surface coefficient of heat transfer	h, (α)	$q = h(T_s - T_r)$ where T_s is the temperature of the surface and T_r is a reference temperature characteristic of the external surroundings	

Units				HEAT (*continued*)
Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
4-3.a	reciprocal kelvin, kelvin to the power minus one	K^{-1}		
4-4.a	pascal per kelvin	Pa/K		
4-5.a	reciprocal pascal, pascal to the power minus one	Pa^{-1}		
4-6.a	joule	J		
4-7.a	watt	W		
4-8.a	watt per square metre	W/m^2		
4-9.a	watt per metre kelvin	$W/(m \cdot K)$		
4-10.a	watt per square metre kelvin	$W/(m^2 \cdot K)$		