INTERNATIONAL STANDARD ISO 31/IV

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Quantities and units of heat

Grandeurs et unités de chaleur

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 31/IV was developed by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors and conversion tables*, and was circulated to the member bodies in October 1975.

It has been approved by the member bodies of the following countries :

Australia	Hungary	Romania
Austria	India	South Africa, Rep. of
Belgium	Israel	Sri Lanka
Brazil	Italy	Sweden
Canada	Mexico	Turkey
Czechoslovakia	Netherlands	United Kingdom
Denmark	Norway	U.S.A.
Finland	Pakistan	Yugoslavia
France	Poland	
Germany	Portugal	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Japan*
Switzerland
U.S.S.R.

* Disagreement concerning the decimal marker only.

This International Standard cancels and replaces ISO Recommendation R 31/IV-1960, of which it constitutes a technical revision.

Quantities and units of heat

INTRODUCTION

This document, containing a table of *quantities and units of heat*, is part IV of ISO 31, which deals with quantities and units in the various fields of science and technology. The complete list of parts of ISO 31 is as follows :

Part 0 : *General introduction — General principles concerning quantities, units and symbols.*

Part I : *Quantities and units of space and time.*

Part II : *Quantities and units of periodic and related phenomena.*

Part III : *Quantities and units of mechanics.*

Part IV : *Quantities and units of heat.*

Part V : *Quantities and units of electricity and magnetism.*

Part VI : *Quantities and units of light and related electromagnetic radiations.*

Part VII : *Quantities and units of acoustics.*

Part VIII : *Quantities and units of physical chemistry and molecular physics.*

Part IX : *Quantities and units of atomic and nuclear physics.*

Part X : *Quantities and units of nuclear reactions and ionizing radiations.*

Part XI : *Mathematical signs and symbols for use in the physical sciences and technology.*

Part XII : *Dimensionless parameters.*

Part XIII : *Quantities and units of solid state physics.*

Arrangement of the tables

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

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 symbol for the quantity is given[1]; where two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing.

Tables of units

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

The units are arranged in the following way :

1) The names of the SI units are given in large print (larger than text size). The SI units and their decimal multiples and sub-multiples formed by means of the SI prefixes are particularly recommended. The decimal multiples and sub-multiples are not explicitly mentioned.

2) 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).

1) When two types of sloping letters exist (for example as with ϑ, θ; φ, ϕ; and g, g) only one of these is given. This does not mean that the other is not equally acceptable.

3) The names of non-SI units which may be used temporarily together with SI units are given in small print (smaller than text size).

The units in classes 2 and 3 are separated by a broken line from the SI units for the quantities concerned.

4) Non-SI units which should not be used together with SI units are given in annexes in some parts of ISO 31. The annexes are not integral parts of the standards. They are arranged in three groups :

a) *Units of the CGS-system with special names*

It is generally preferable not to use CGS-units with special names and symbols together with SI units.

b) *Units based on the foot, pound and second and some other units*

c) *Other units*

These are given for information, especially regarding the conversion factor. The use of those units marked with ÷ is deprecated.

Remark on supplementary units

The Conférence générale des poids et mesures (CGPM : General Conference for Weights and Measures) has classified the SI units, radian and steradian, as "supplementary units", deliberately leaving open the question of whether they are base units or derived units, and consequently the question of whether angle and solid angle are to be considered as base quantities or derived quantities.

In ISO 31, plane angle and solid angle are treated as derived quantities (see also part 0). They are defined in ISO 31 as ratios of two lengths and of two areas respectively, and consequently they are treated as dimensionless quantities. Although in this treatment the coherent unit for both quantities is the number 1, it is convenient to use the special names radian and steradian instead of the number 1 in many practical cases.

If plane angle and solid angle were treated as base quantities, the units radian and steradian would be base units and could not be considered as special names for the number 1. Such a treatment would require extensive changes in ISO 31.

Number of digits in numerical statements[1)]

All numbers in the column "Definition" are exact.

In the column "Conversion factors", the conversion factors on which the calculation of others are based are normally given to seven significant digits. When they are exact and contain seven or fewer digits and where it is not obvious from the context, the word "exactly" is added, but when they can be terminated after more than seven digits, they may be given in full. When the conversion factors are derived from experiment, they are given with the number of significant digits justified by the accuracy of the experiments. Generally, this means that in such cases the last digit only is in doubt. When, however, experiment justifies more than seven digits, the factor is usually rounded off to seven significant digits.

The other conversion factors are given to not more than six significant digits; when they are exactly known and contain six or fewer digits and where it is not obvious from the context, the word "exactly" is added.

Numbers in the column "Remarks" are given to a precision appropriate to the particular case.

1) The decimal sign is a comma on the line. In documents in the English language, a comma or a dot on the line may be used.

4. Heat

Quantities
4-1.1 . . . 4-2.1

Item No.	Quantity	Symbol	Definition	Remarks
4-1.1	thermodynamic temperature	T, Θ		The thermodynamic temperature is defined according to the principles of thermodynamics
4-2.1	Celsius temperature	t, θ	$t = T - T_0$ where T_0 is fixed by convention to be $T_0 = 273{,}15$ K	The thermodynamic temperature T_0 is by definition 0,01 K below the thermodynamic temperature of the triple point of water

4. Heat

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	Remarks
4-1.a	kelvin	K	The kelvin, unit of thermodynamic temperature, is the fraction 1/273,16 of the thermodynamic temperature of the triple point of water		**Temperature interval** The units of thermodynamic and Celsius temperature interval or difference are identical. The Conférence générale des poids et mesures 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" or "degree", should be abandoned. **The "I.P.T.S. (1968)"** For the purpose of practical measurements, the Conférence générale des poids et mesures introduced the International Practical Temperature Scale. This temperature scale is based on a number of fixed points and interpolation procedures with the help of certain measuring instruments and defines the temperature down to 13,81 K. The last version, approved in 1976, is an amended edition of the International Practical Temperature Scale 1968. The thermodynamic temperature and Celsius temperature defined by this scale are indicated as T_{68} and t_{68} respectively, where $t_{68} = T_{68} - T_0$ T_{68} and t_{68} are considered to be the best approximations at present to T and t respectively. The units of T_{68} and t_{68} are the kelvin and degree Celsius respectively, as in the case of T and t [for complete text, see : *Metrologia* 12 (1976) No. 1]. The previously accepted "helium scales" deviate too much from the thermodynamic temperature at low temperatures and have therefore been withdrawn.
4-2.a	degree Celsius	°C	Degree Celsius is a special name for the unit kelvin for use in stating values of Celsius temperature		

4. Heat (continued)

Quantities
4-3.1 . . . 4-11.1

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 subscripts in the symbols may be omitted when no confusion will result The name pressure coefficient and the symbol β are also used for the quantity 4-3.3 The quantities 4-3.1 to 4-5.1 are not completely defined unless the type of change is specified
4-3.2	cubic expansion coefficient	α_V, γ	$\alpha_V = \frac{1}{V}\frac{\mathrm{d}V}{\mathrm{d}T}$	
4-3.3	relative pressure coefficient	α_p	$\alpha_p = \frac{1}{p}\frac{\mathrm{d}p}{\mathrm{d}T}$	
4-4.1 (4-3.3)	pressure coefficient	β	$\beta = \frac{\mathrm{d}p}{\mathrm{d}T}$	
4-5.1 —	compressibility	κ	$\kappa = -\frac{1}{V}\frac{\mathrm{d}V}{\mathrm{d}p}$	
4-6.1 (4-4.1)	heat, quantity of heat	Q		The heat transferred in an isothermal phase transformation, formerly called "latent heat" with symbol L, is better expressed as the change of the appropriate thermodynamic functions, e.g. $T \cdot \Delta S$, where ΔS is the change of entropy, or as ΔH
4-7.1 (4-5.1)	heat flow rate	Φ	Rate of heat flow across a surface	
4-8.1 (4-6.1)	density of heat flow rate	q, φ	Heat flow rate divided by area	
4-9.1 (4-7.1)	thermal conductivity	λ, (k)	Density of heat flow rate divided by temperature gradient	
4-10.1 (4-8.1)	coefficient of heat transfer	h, k, K, α	Density of heat flow rate divided by temperature difference	The symbols h and α are used for surface coefficient of heat transfer. The symbols k and K are used for overall coefficient of heat transfer
4-11.1 —	thermal insulance, coefficient of thermal insulation	M	Temperature difference divided by density of heat flow rate	

4. Heat (continued)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	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			For other units, see 3-24.b and c
4-7.a	watt	W			
4-8.a	watt per square metre	W/m^2			
4-9.a	watt per metre kelvin	W/(m·K)			
4-10.a	watt per square metre kelvin	$W/(m^2 \cdot K)$			
4-11.a	square metre kelvin per watt	$m^2 \cdot K/W$			