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Quantities and units —

Part 5:
Thermodynamics

Grandeurs et unités —

Partie 5: Thermodynamique

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www. iso. org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www. iso .org/iso/foreword. html.

This document was prepared by Technical Committee ISO/TC 12, *Quantities and units*, in collaboration with Technical Committee IEC/TC 25, *Quantities and units*.

This second edition cancels and replaces the first edition (ISO 80000-5:2007), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the table giving the quantities and units has been simplified;

— some definitions and the remarks have been stated physically more precisely.

A list of all parts in the ISO 80000 and IEC 80000 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Quantities and units —

Part 5:
Thermodynamics

1 Scope

This document gives names, symbols, definitions and units for quantities of thermodynamics. Where appropriate, conversion factors are also given.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

Names, symbols, definitions and units for quantities used in thermodynamics are given in Table 1.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

Table 1 — Quantities and units used in thermodynamics

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
5-1	thermodynamic temperature	T, Θ	partial derivative of internal energy with respect to entropy at constant volume and constant number of particles in the system: $T = \left(\frac{\partial U}{\partial S}\right)_{V,N}$ where U is internal energy (item 5-20.2), S is entropy (item 5-18), V is volume (ISO 80000-3), and N is number of particles	K	It is measured with a primary thermometer, examples of which are gas thermometers of different kinds, noise thermometers, or radiation thermometers. The Boltzmann constant (ISO 80000-1) relates energy at the individual particle level with thermodynamic temperature. Differences of thermodynamic temperatures or changes may be expressed either in kelvin, symbol K, or in de grees Celsius, symbol °C (item 5-2). Thermodynamic temperature is one of the seven base quantities in the International System of Quantities, ISQ (see ISO 80000-1). **The International Temperature Scale of 1990** For the purpose of practical measurements, the International Temperature Scale of 1990, ITS-90, was adopted by CIPM in 1989, which is a close approximation to the thermodynamic temperature scale. The quantities defined by this scale are denoted T_{90} and t_{90}, respectively (replacing T_{68} and t_{68} defined by the International Practical Temperature Scale of 1968, IPTS-68), where $\frac{t_{90}}{1\,°\text{C}} = \frac{T_{90}}{1\,\text{K}} - 273{,}15$

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
5-1 *(cont.)*					The units of T_{90} and t_{90} are the kelvin, symbol K, and the degree Celsius, symbol °C (item 5-2), respectively. For further information, see References[5],[6]. For ready conversion between temperatures reported on the International Temperature Scale and thermodynamic temperatures the systematic deviations can be found in Reference[7].
5-2	Celsius temperature	t, ϑ	temperature difference from the thermodynamic temperature of the ice point is called the Celsius temperature t, which is defined by the quantity equation: $t = T - T_0$ where T is thermodynamic temperature (item 5-1) and $T_0 = 273{,}15\ \text{K}$	°C	The unit degree Celsius is a special name for the kelvin for use in stating values of Celsius temperature. The unit degree Celsius is by definition equal in magnitude to the kelvin. A difference or interval of temperature may be expressed in kelvin or in degrees Celsius. The thermodynamic temperature T_0 is 0,01 K below the thermodynamic temperature of the triple point of water. The symbol °C for the degree Celsius shall be preceded by a space (see ISO 80000-1). Prefixes are not allowed in combination with the unit °C.
5-3.1	linear expansion coefficient	α_l	relative change of length with temperature: $\alpha_l = \frac{1}{l}\frac{\text{d}l}{\text{d}T}$ where l is length (ISO 80000-3) and T is thermodynamic temperature (item 5-1)	K^{-1}	The subscripts in the symbols may be omitted when there is no risk of confusion.
5-3.2	cubic expansion coefficient	α_V, γ	relative change of volume with temperature: $\alpha_V = \frac{1}{V}\frac{\text{d}V}{\text{d}T}$ where V is volume (ISO 80000-3) and T is thermodynamic temperature (item 5-1)	K^{-1}	Also called volumetric expansion coefficient. The subscripts in the symbols may be omitted when there is no risk of confusion.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
5-3.3	relative pressure coefficient	α_p	relative change of pressure with temperature at constant volume: $\alpha_p = \frac{1}{p}\left(\frac{\partial p}{\partial T}\right)_V$ where p is pressure (ISO 80000-4), T is thermodynamic temperature (item 5-1), and V is volume (ISO 80000-3)	K^{-1}	The subscripts in the symbols may be omitted when there is no risk of confusion.
5-4	pressure coefficient	β	change of pressure with temperature at constant volume: $\beta = \left(\frac{\partial p}{\partial T}\right)_V$ where p is pressure (ISO 80000-4), T is thermodynamic temperature (item 5-1), and V is volume (ISO 80000-3)	Pa/K $kg\ m^{-1}\ s^{-2}\ K^{-1}$	
5-5.1	isothermal compressibility	$\varkappa_T$	negative relative change of volume with pressure at constant temperature: $\varkappa_T = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_T$ where V is volume (ISO 80000-3), p is pressure (ISO 80000-4), and T is thermodynamic temperature (item 5-1)	Pa^{-1} $kg^{-1}\ m\ s^2$	The subscripts in the symbols may be omitted when there is no risk of confusion.
5-5.2	isentropic compressibility	$\varkappa_S$	negative relative change of volume with pressure at constant entropy: $\varkappa_S = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_S$ where V is volume (ISO 80000-3), p is pressure (ISO 80000-4), and S is entropy (item 5-18)	Pa^{-1} $kg^{-1}\ m\ s^2$	The subscripts in the symbols may be omitted when there is no risk of confusion.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
5-6.1	heat, amount of heat	Q	difference between the increase in the internal energy (item 5-20.2) of a system and the work (ISO 80000-4) done on the system, provided that the amounts of substances within the system are not changed	J kg m^2 s^{-2}	The heat transferred in an isothermal phase transformation should be expressed as the change in the appropriate state functions, e.g. $T\,\Delta S$, where T is thermodynamic temperature (item 5-1) and S is entropy (item 5-18), or ΔH, where H is enthalpy (item 5-20.3). NOTE A supply of heat can correspond to an increase in thermodynamic temperature or to other effects, such as phase change or chemical processes; see item 5-6.2.
5-6.2	latent heat	Q	energy released or absorbed by a system during a constant-temperature process	J kg m^2 s^{-2}	Examples of latent heat are latent heat of fusion (melting) and latent heat of vaporization (boiling).
5-7	heat flow rate	$\dot{Q}$	time rate at which heat (item 5-6.1) crosses a given surface	W J/s kg m^2 s^{-3}	
5-8	density of heat flow rate	q, φ	quotient of heat flow rate and area: $q = \frac{\dot{Q}}{A}$ where $\dot{Q}$ is heat flow rate (item 5-7) and A is area (ISO 80000-3) of a given surface	W/m^2 kg s^{-3}	
5-9	thermal conductivity	λ, ($\varkappa$)	quotient of density of heat flow rate (item 5-8) and thermodynamic temperature gradient that has the same direction as the heat flow	W/(m K) kg m s^{-3} K^{-1}	
5-10.1	coefficient of heat transfer	K, (k)	quotient of density of heat flow rate (item 5-8) and thermodynamic temperature (item 5-1) difference	W/(m^2 K) kg s^{-3} K^{-1}	In building technology, the coefficient of heat transfer is often called thermal transmittance, with the symbol U (no longer recommended). See remark to item 5-13.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
5-10.2	surface coefficient of heat transfer	h, (α)	quotient of density of heat flow rate and the difference of the temperature at the surface and a reference temperature: $h = \frac{q}{(T_s - T_r)}$ where q is density of heat flow rate (item 5-8), T_s is the thermodynamic temperature (item 5-1) at the surface, and T_r is a reference thermodynamic temperature characterizing the adjacent surroundings	W/(m^2 K) kg s^{-3} K^{-1}	
5-11	thermal insulance, coefficient of thermal insulance	M	inverse of coefficient of heat transfer K: $M = \frac{1}{K}$ where K is coefficient of heat transfer (item 5-10.1)	m^2 K/W kg^{-1} s^3 K	In building technology, this quantity is often called thermal resistance, with the symbol R.
5-12	thermal resistance	R	quotient of thermodynamic temperature (item 5-1) difference and heat flow rate (item 5-7)	K/W kg^{-1} m^{-2} s^3 K	See remark to item 5-11.
5-13	thermal conductance	G, (H)	inverse of thermal resistance R: $G = \frac{1}{R}$ where R is thermal resistance (item 5-12)	W/K kg m^2 s^{-3} K^{-1}	See remark to item 5-11. This quantity is also called heat transfer coefficient. See item 5-10.1.
5-14	thermal diffusivity	a	quotient of thermal conductivity and the product of mass density and specific heat capacity: $a = \frac{\lambda}{\rho c_p}$ where λ is thermal conductivity (item 5-9), ρ is mass density (ISO 80000-4), and c_p is specific heat capacity at constant pressure (item 5-16.2)	m^2 s^{-1}	

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
5-15	heat capacity	C	derivative of added heat with respect to thermodynamic temperature of a system: $C = \frac{dQ}{dT}$ where Q is amount of heat (item 5-6.1) and T is thermodynamic temperature (item 5-1)	J/K kg m^2 s^{-2} K^{-1}	Heat capacity is not completely defined unless specified as seen in items 5-16.2, 5-16.3 and 5-16.4.
5-16.1	specific heat capacity	c	quotient of heat capacity and mass: $c = \frac{C}{m}$ where C is heat capacity (item 5-15) and m is mass (ISO 80000-4)	J/(kg K) m^2 s^{-2} K^{-1}	For the corresponding quantities related to the amount of substance, see ISO 80000-9.
5-16.2	specific heat capacity at constant pressure	c_p	specific heat capacity (item 5-16.1) at constant pressure (ISO 80000-4)	J/(kg K) m^2 s^{-2} K^{-1}	Also called specific isobaric heat capacity.
5-16.3	specific heat capacity at constant volume	c_V	specific heat capacity (item 5-16.1) at constant volume (ISO 80000-3)	J/(kg K) m^2 s^{-2} K^{-1}	Also called specific isochoric heat capacity.
5-16.4	specific heat capacity at saturated vapour pressure	c_{sat}	specific heat capacity (item 5-16.1) at saturated vapour pressure (ISO 80000-4)	J/(kg K) m^2 s^{-2} K^{-1}	
5-17.1	ratio of specific heat capacities	γ	quotient of specific heat capacity at constant pressure and specific heat capacity at constant volume: $\gamma = \frac{c_p}{c_V}$ where c_p is specific heat capacity at constant pressure (item 5-16.2) and c_V is specific heat capacity at constant volume (item 5-16.3)	1	This quantity can also be expressed by $\gamma = \frac{C_p}{C_V}$ where C_p is heat capacity at constant pressure and C_V is heat capacity at constant volume.