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UNITS AND SYMBOLS FOR REFRIGERATION

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BRIEF HISTORY

The ISO Recommendation R 786, *Units and symbols for refrigeration*, was drawn up by Technical Committee ISO/TC 86, *Refrigeration*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question by the Technical Committee began in 1962 and led, in 1965, to the adoption of a Draft ISO Recommendation.

In November 1966, this Draft ISO Recommendation (No. 1053) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature,by the following Member Bodies :

Australia	Hungary	Switzerland
Belgium	Ireland	Turkey
Brazil	Israel	U.A.R.
Canada	Italy	United Kingdom
Chile	Japan	U.S.S.R.
Denmark	Korea, Rep. of	Yugoslavia
France	Norway	

Four Member Bodies opposed the approval of the Draft :

Czechoslovakia	Poland
Netherlands	Sweden

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in July 1968, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 786 July 1968

UNITS AND SYMBOLS FOR REFRIGERATION

INTRODUCTION

This ISO Recommendation is a collection of the principal quantities chiefly used in the field of refrigeration, and of their symbols and units of measurement. For convenience, certain fundamental quantities and their derivatives have been included, which have already been considered in ISO Recommendation R 31.

The various quantities have been grouped in a logical order so as to facilitate their location by users.

In certain cases, when the same symbol may have more than one meaning, a second symbol has been proposed. The units are separated into two columns, the first giving units of the Système International (SI) and the second units of other systems which are at present very widely used. In order to obtain the values in SI units which are equivalent to those in other units, conversion factors have been introduced near the latter.

A column reserved for "Definitions and Remarks" in the tables provides in certain cases definitions or explanations supplementary to those found in ISO Recommendation R 31.

The use of metric and SI units and their multiples and sub-multiples is particularly recommended.

1. INDEXES FOR SPECIAL CASES

When it is necessary to define certain quantities by means of indexes, it is advisable to make use of the following indications, the meaning of which should in every case be given.

Inferior indexes

1, 2, 3 . . .	relating to different points of a system or of a cycle, or to different time intervals
a	relating to air or to an adiabatic process
e	” to effective
f	” to an intermediate agent
i	” to “indicated” or to an isenthalpic process
k	” to upper pressure or temperature
l	” to length
m	” to mass or mechanical
o	” to a lower pressure or temperature
p	” to pressure, or to a polytropic process
s	” to a state of saturation, or to an isentropic process
t	” to temperature or to an isothermal process
v	” to volume
w	” to water

Superior indexes

''	relating to the gaseous phase
'	” ” ” liquid ”
o	” ” ” solid ”

Upper bar

Relating to the boundary layer, along the surface of separation between two phases, or to the mean value of a quantity (e.g. mean speed).

2. TABLE OF SYMBOLS AND UNITS

Quantity	Symbol	Dimensions	SI units	
			Name	Symbol
length	l	L	metre	m
area, surface	A	L^2	square metre	m^2
volume	V	L^3	cubic metre	m^3
mass	m	M	kilogramme	kg
time	t	T	second	s
frequency	ν, f	T^{-1}	hertz	Hz
rotational speed	n	T^{-1}	hertz	Hz
density (mass density)	ρ	ML^{-3}	kilogramme per cubic metre	kg/m^3
specific volume	v	L^3M^{-1}	cubic metre per kilogramme	m^3/kg
mass flow rate	q_m	MT^{-1}	kilogramme per second	kg/s
volume flow rate	q_v	L^3T^{-1}	cubic metre per second	m^3/s
thermodynamic or absolute temperature	T, Θ	Θ	kelvin	K
customary temperature	t, θ	Θ		

Other units		Conversion factor	Definitions and remarks
Name	Symbol		
foot inch	ft in	1 ft = 0.3048 m (exactly) 1 in = 0.0254 m (exactly)	
square foot square inch	ft^2 in^2	1 ft^2 = 0.092 903 0 m^2 1 in^2 = 6.4516×10^{-4} m^2 (exactly)	
cubic foot cubic inch	ft^3 in^3	1 ft^3 = 28.3168×10^{-3} m^3 1 in^3 = 16.3871×10^{-6} m^3	
pound	lb	1 lb = 0.453 592 37 kg (exactly)	
minute hour	min h	1 min = 60 s 1 h = 3600 s	
			Also called "cycle per second".
revolution per minute	min^{-1}	1 min^{-1} = $\frac{1}{60}$ Hz	
pound per cubic foot	lb/ft^3	1 lb/ft^3 = 16.0185 kg/m^3	
cubic foot per pound	ft^3/lb	1 ft^3/lb = 0.0624 m^3/kg	
pound per hour	lb/h	1 lb/h = 126×10^{-6} kg/s	Fluid mass flowing in unit time.
cubic foot per hour	ft^3/h	1 ft^3/h = $7.865\ 79 \times 10^{-6}$ m^3/s	Fluid volume flowing in unit time.
Rankine degree	°R	$T_K = \frac{5}{9} T_R$	If t_C °C, t_F °F, T_K K and T_R °R are referring to one and the same physical state, the figures t_C, t_F, T_K and T_R are evaluated as $t_C = \frac{5}{9}(t_F - 32)$ $= T_K - 273.15$ $= \frac{5}{9} T_R - 273.15$
Celsius degree Fahrenheit degree	°C °F	$t_C = \frac{5}{9}(t_F - 32)$	$t_C = T_K - 273.15$ $t_F = T_R - 459.67$

2. **TABLE OF SYMBOLS AND UNITS** *(continued)*

Quantity	Symbol	Dimensions	SI units	
			Name	Symbol
temperature difference	Δt, $\Delta \theta$ ΔT, $\Delta \Theta$	Θ	kelvin	K
coefficient of linear thermal expansion	α_l	Θ^{-1}	per kelvin	K^{-1}
coefficient of volume thermal expansion	α_V	Θ^{-1}	per kelvin	K^{-1}
coefficient of thermal pressure increase	β	Θ^{-1}	per kelvin	K^{-1}
coefficient of compressibility	χ	$M^{-1}LT^2$	square metre per newton	m^2/N
force	F	MLT^{-2}	newton	N
pressure	p	$ML^{-1}T^{-2}$	newton per square metre	N/m^2
surface tension	σ	MT^{-2}	newton per metre	N/m

Other units		Conversion factor	Definitions and remarks
Name	Symbol		
Celsius degree Fahrenheit degree	°C °F	 $1\ °F = \frac{5}{9}\ K$	
per Celsius degree per Fahrenheit degree	$°C^{-1}$ $°F^{-1}$	 $1\ °F^{-1} = \frac{9}{5}\ K^{-1}$	$\alpha_l = \frac{1}{l}\frac{dl}{dt}$
per Celsius degree per Fahrenheit degree	$°C^{-1}$ $°F^{-1}$	 $1\ °F^{-1} = \frac{9}{5}\ K^{-1}$	$\alpha_V = \frac{1}{V}\left(\frac{dV}{dt}\right)_p$
per Celsius degree per Fahrenheit degree	$°C^{-1}$ $°F^{-1}$	 $1\ °F^{-1} = \frac{9}{5}\ K^{-1}$	$\beta = \frac{1}{p}\left(\frac{dp}{dt}\right)_V$
square inch per pound-force	in^2/lbf	$1\ in^2/lbf = 1.450\ 37 \times 10^{-4}\ m^2/N$	$\chi_{t,...} = -\frac{1}{V}\left(\frac{dV}{dp}\right)_{t,...}$
dyne kilogramme-force pound-force	dyn kgf lbf	$1\ dyn = 10^{-5}\ N$ (exactly) 1 kgf = 9.806 65 N (exactly) 1 lbf = 4.448 22 N	 Also called "kilopond" (kp).
-------	-------	-------	This unit is also called "pascal".
bar	bar	$1\ bar = 10^5\ N/m^2$ (exactly)	1 bar = 1 hectopieze (hpz)
kilogramme-force per square centimetre	kgf/cm^2	$1\ kgf/cm^2 = 98\ 066.5\ N/m^2$ (exactly)	$1\ kgf/cm^2$ = 1 technical atmosphere (at)
normal atmosphere	atm	$1\ atm = 101\ 325\ N/m^2$ (exactly)	
pound-force per square foot	lbf/ft^2	$1\ lbf/ft^2 = 47.8803\ N/m^2$	
pound-force per square inch	lbf/in^2	$1\ lbf/in^2 = 6894.76\ N/m^2$	
millimetre of water*	mmH_2O	$1\ mmH_2O = 9.806\ 65\ N/m^2$ (exactly)	
millimetre of mercury*	mmHg	$1\ mmHg = 133.322\ N/m^2$	1 mmHg = 1 torr
inch of water*	inH_2O	$1\ inH_2O = 249.089\ N/m^2$	
inch of mercury*	inHg	$1\ inHg = 3386.39\ N/m^2$	
dyne per centimetre	dyn/cm	$1\ dyn/cm = 10^{-3}\ N/m$ (exactly)	

* Conventional units.

2. **TABLE OF SYMBOLS AND UNITS** (*continued*)

Quantity	Symbol	Dimensions	SI units	
			Name	Symbol
dynamic viscosity	μ	$ML^{-1}T^{-1}$	newton second per square metre	$N{\cdot}s/m^2$
kinematic viscosity	ν	L^2T^{-1}	square metre per second	m^2/s
work	W	ML^2T^{-2}	joule	J
power	P	ML^2T^{-3}	watt	W
specific work	w	L^2T^{-2}	joule per kilogramme	J/kg
heat quantity	Q	ML^2T^{-2}	joule	J
heat flow rate	Φ	ML^2T^{-3}	watt	W

Other units		Conversion factor	Definitions and remarks
Name	Symbol		
poise	P	1 P = 0.1 $N \cdot s/m^2$ (exactly)	1 $N \cdot s/m^2$ = 1 $kg/(m \cdot s)$ 1 P = 1 $dyn \cdot s/cm^2$ = 1 $g/(cm \cdot s)$
kilogramme-force second per square metre	$kgf \cdot s/m^2$	1 $kgf \cdot s/m^2$ = 9.806 65 $N \cdot s/m^2$ (exactly)	
pound-force second per square foot	$lbf \cdot s/ft^2$	1 $lbf \cdot s/ft^2$ = 47.8803 $N \cdot s/m^2$	
stokes	St	1 St = 0.0001 m^2/s	1 St = 1 cm^2/s
square foot per second	ft^2/s	1 ft^2/s = 0.092 903 0 m^2/s	
kilowatt hour	kWh	1 kWh = 3.6×10^6 J (exactly)	
erg	erg	1 erg = 10^{-7} J (exactly)	
kilogramme-force metre	$kgf \cdot m$	1 $kgf \cdot m$ = 9.806 65 J (exactly)	
foot pound-force	$ft \cdot lbf$	1 $ft \cdot lbf$ = 1.355 82 J	
horsepower	hp	1 hp = 745.700 W	1 hp = 550 $ft \cdot lbf/s$
cheval vapeur	ch	1 ch = 735.499 W	1 ch = 75 $kgf \cdot m/s$
foot pound-force per pound	$ft \cdot lbf/lb$	1 $ft \cdot lbf/lb$ = 2.9890 J/kg	The work done per unit of mass.
international kilocalorie	$kcal_{IT}$	1 $kcal_{IT}$ = 4186.8 J (exactly)	1 kWh = 859.845 $kcal_{IT}$
kilocalorie at 15 °C	$kcal_{15}$	1 $kcal_{15}$ = 4185.5 J	In the refrigeration field, the unit "frigorie" (fg) is also used, corresponding to an extraction of 1 $kcal_{15}$ from the body to be cooled.
British thermal unit	Btu	1 Btu = 1055.06 J	1 $kcal_{IT}$ = 3.968 Btu
international kilocalorie per hour	$kcal_{IT}/h$	1 $kcal_{IT}/h$ = 1.163 W (exactly)	
British thermal unit per hour	Btu/h	1 Btu/h = 0.293 071 W	

2. TABLE OF SYMBOLS AND UNITS (*continued*)

Quantity	Symbol	Dimensions	SI units	
			Name	Symbol
density of heat flow rate	φ	MT^{-3}	watt per square metre	W/m^2
heat transfer capacity (heat load)	Φ_k	ML^2T^{-3}	watt	W
refrigerating capacity	Φ_o	ML^2T^{-3}	watt	W
efficiency	η			
indicated efficiency	η_i			
mechanical efficiency	η_m			
volumetric efficiency	η_v			

Other units		Conversion factor	Definitions and remarks
Name	Symbol		
international kilocalorie per hour square metre	$kcal_{IT}/(h \cdot m^2)$	$1\ kcal_{IT}/(h \cdot m^2) = 1.163\ W/m^2$ (exactly)	
British thermal unit per hour square foot	$Btu/(h \cdot ft^2)$	$1\ Btu/(h \cdot ft^2) = 3.154\,59\ W/m^2$	
international kilocalorie per hour	$kcal_{IT}/h$	$1\ kcal_{IT}/h = 1.163\ W$ (exactly)	Heat flow rate rejected to the hot body from a refrigerating machine.
kilocalorie at 15 °C per hour	$kcal_{15}/h$	$1\ kcal_{15}/h = 1.1626\ W$	
British thermal unit per hour	Btu/h	1 Btu/h = 0.293 071 W	
frigorie per hour	fg/h	1 fg/h = 1.1626 W	$1\ fg/h = 1\ kcal_{15}/h$
ton of refrigeration	ton	1 ton = 3516.85 W	1 ton of refrigeration = a heat flow rate of 12 000 Btu/h removed by the refrigerating system from the cold body.
			Ratio of the indicated power of a compressor to the ideal power with isothermal compression.
			Ratio of the indicated power of a compressor to the input power.
			Ratio of the fluid volume drawn in during the suction time at the suction conditions to the volume displaced in the cylinder or cylinders of the compressor.

2. **TABLE OF SYMBOLS AND UNITS** *(continued)*

Quantity	Symbol	Dimensions	SI units	
			Name	Symbol
isentropic efficiency of adiabatic compression	η_s			
isothermal compression efficiency	η_t			
refrigerating performance	$\epsilon\,[\zeta]$			
refrigerating capacity per unit volume	q_o	$ML^{-1}T^{-2}$	joule per cubic metre	J/m^3

Other units		Conversion factor	Definitions and remarks
Name	Symbol		
			Ratio of the power of an isentropic compression (reversible adiabatic) to the actual power supplied to the same fluid mass flow rate from the initial to the final state (difference of enthalpies).
			Ratio of the power with reversible isothermal compression to the actual power supplied to the same fluid mass flow rate from the initial to the final state.
international kilocalorie per watt hour	$kcal_{IT}/(W \cdot h)$	$1\ kcal_{IT}/h = 1.163\ W$ (exactly)	Ratio of the refrigerating capacity to the absorbed power (for a cycle, a machine, a compressor, etc.).
international kilocalorie per cheval hour	$kcal_{IT}/(ch \cdot h)$	$1\ kcal_{IT}/h = 0.001\ 58\ ch$	
British thermal unit per horsepower hour	Btu/(hp·h)	1 Btu/h = 0.000 393 hp	
British thermal unit per watt hour	Btu/(W·h)	1 Btu/h = 0.293 W	
ton of refrigeration per horsepower	ton/hp	1 ton = 4.716 hp	
frigorie per kilocalorie	fg/kcal		
international kilocalorie per cubic metre	$kcal_{IT}/m^3$	$1\ kcal_{IT}/m^3 = 4186.8\ J/m^3$ (exactly)	Ratio of the refrigerating capacity to the volume flow rate in a clearly defined condition.

2. TABLE OF SYMBOLS AND UNITS (*continued*)

Quantity	Symbol	Dimensions	SI units	
			Name	Symbol
internal energy enthalpy free energy free enthalpy exergy latent heat of transformation	*U* *H* *F* *G* *E* *L*	ML^2T^{-2}	joule	J
specific internal energy specific enthalpy specific free energy specific free enthalpy specific exergy specific latent heat of transformation	*u* *h* *f* *g* *e* *l*	L^2T^{-2}	joule per kilogramme	J/kg
specific humidity	x			
relative humidity	φ_p			
saturation ratio	ψ			

Other units		Conversion factor	Definitions and remarks
Name	Symbol		
international kilocalorie British thermal unit	$kcal_{IT}$ Btu	1 $kcal_{IT}$ = 4186.8 J (exactly) 1 Btu = 1055.06 J	$E = (H-H_e) - T_e (S-S_e)$ Also called "vaporization enthalpy difference", "fusion enthalpy difference", "latent heat", etc. The type of transformation should be indicated in each case.
international kilocalorie per kilogramme British thermal unit per pound	$kcal_{IT}$/kg Btu/lb	1 $kcal_{IT}$/kg = 4186.8 J/kg (exactly) 1 Btu/lb = 2326 J/kg (exactly)	$e = (h-h_e) - T_e (s-s_e)$
			Ratio of the mass of moisture in humid air to the mass of dry air present in the mixture.
			Ratio of the water vapour partial pressure to the saturation pressure of pure water vapour at the same temperature.
			Ratio of the actual specific humidity to the specific humidity of saturated air at the same temperature. NOTE. – For temperatures less than 0 °C the values in general apply to pure water ice. When applied to subcooled water the symbols should be qualified by a special index.

2. **TABLE OF SYMBOLS AND UNITS** *(continued)*

Quantity	Symbol	Dimensions	SI units	
			Name	Symbol
entropy	S	$ML^2T^{-2}\Theta^{-1}$	joule per kelvin	J/K
specific entropy	s	$L^2T^{-2}\Theta^{-1}$	joule per kilogramme kelvin	J/(kg·K)
heat capacity	C	$ML^2T^{-2}\Theta^{-1}$	joule per kelvin	J/K
specific heat capacity	c	$L^2T^{-2}\Theta^{-1}$	joule per kilogramme kelvin	J/(kg·K)
specific heat capacity at constant pressure	c_p	$L^2T^{-2}\Theta^{-1}$	joule per kilogramme kelvin	J/(kg·K)
specific heat capacity at constant volume	c_v	$L^2T^{-2}\Theta^{-1}$	joule per kilogramme kelvin	J/(kg·K)
ratio of specific heat capacities	γ [κ]			
thermal conductivity	λ	$MLT^{-3}\Theta^{-1}$	watt per metre kelvin	W/(m·K)
equivalent conductivity	λ_e	$MLT^{-3}\Theta^{-1}$	watt per metre kelvin	W/(m·K)