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Quantities and units of acoustics

Grandeurs et unités d'acoustique

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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/VII was developed by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors and conversion tables*, and was circulated to the member bodies in August 1975.

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

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

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/VII-1965, of which it constitutes a technical revision.

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Quantities and units of acoustics

INTRODUCTION

This document, containing a table of *quantities and units of acoustics*, is part VII 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 standard. 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.

SPECIAL REMARKS

The explanations in the "Definition" column for quantities presuppose, in general, linear systems.

When it is necessary to use subscripts to avoid confusion between similar symbols in different domains, the subscript "a" is recommended for the acoustical case.

Remark on level difference

In ISO 31, level difference is defined as the natural logarithm of the ratio of two quantities of the same kind. It is a dimensionless quantity. Although the coherent unit corresponding to this definition is the number 1, it is convenient in practice to use the special namer neper.

The expression for level difference in terms of Briggsian logarithms follows from the definition.

The relation between the neper and the decibel, the units commonly used for expressing level difference, is

$$1\ \mathrm{dB} = \frac{\ln 10}{20}\ \mathrm{Np}$$

The relation between the bel and decibel is 1 dB = 10^{-1} B, but only the decibel is given in ISO 31 since the bel is not often used.

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.

Quantities
7-1.1 . . . 7-12.1

7. Acoustics

Item No.	Quantity	Symbol	Definition	Remarks
7-1.1	period, periodic time	T	Time of one cycle	
7-2.1	frequency	f, ν	$f = 1/T$	Concerning the standard turning frequency (standard musical pitch), see ISO 16
7-3.1	frequency interval		The frequency interval between two frequencies is the logarithm of the ratio of the higher frequency to the lower frequency	This quantity is dimensionless
7-4.1	angular frequency, circular frequency, pulsatance	ω	$\omega = 2\pi f$	
7-5.1	wavelength	λ		
7-6.1	circular wave number	k	$k = 2\pi/\lambda$ $= 2\pi\sigma$ where σ is the wave number, $\sigma = 1/\lambda$	The corresponding vector quantity is called propagation vector
7-7.1	density (mass density)	ϱ	Mass divided by volume	
7-8.1	static pressure	p_s	Pressure that would exist in the absence of sound waves	
7-8.2	(instantaneous) sound pressure	$p, (p_a)$	The difference between the instantaneous total pressure and the static pressure	The root mean square values of the quantities 7-8.2 to 7-12.1 are often called "effective" values, and the same symbols are often used without modification to denote the effective values.
7-9.1	(instantaneous) sound particle displacement	$\xi, (x)$	Instantaneous displacement of a particle of the medium from what would be its position in the absence of sound waves	
7-10.1	(instantaneous) sound particle velocity	u, v	$u = \frac{\partial \xi}{\partial t}$	
7-11.1	(instantaneous) sound particle acceleration	a	$a = \frac{\partial u}{\partial t}$	
7-12.1	(instantaneous) volume flow rate, volume velocity	q, U	Instantaneous rate of volume flow due to the sound wave	

7. Acoustics

Units
7-1.a . . . 7-12. a

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	Remarks
7-1.a	second	s			
7-2.a	hertz	Hz	1 Hz is the frequency of a periodic phenomenon of which the period is 1 s		1 Hz = 1 s^{-1}
7-3.a	octave		The frequency interval between f_1 and f_2 is one octave if $f_2/f_1 = 2$		The numerical value of the frequency interval in octaves is given by lb (f_2/f_1), $(f_2 \geqslant f_1)$
7-4.a	reciprocal second, second to the power minus one	s^{-1}			
7-5.a	metre	m			
7-6.a	reciprocal metre, metre to the power minus one	m^{-1}			
7-7.a	kilogram per cubic metre	kg/cm^3			
7-8.a	pascal	Pa			
7-8.b	bar	bar		1 bar = 10^5 Pa (exactly)	
7-9.a	metre	m			
7-10.a	metre per second	m/s			
7-11.a	metre per second squared	m/s^2			
7-12.a	cubic metre per second	m^3/s			

Quantities
7-13.1 . . . 7-18.1

7. Acoustics (continued)

Item No.	Quantity	Symbol	Definition	Remarks
7-13.1	velocity of sound	c, (c_a)	Velocity of a sound wave	
7-14.1	sound energy density	w, (w_a), (E)	Mean sound energy in a given volume divided by that volume	If the energy density is varying with time, the mean must be taken over an interval during which the sound may be considered statistically stationary
7-15.1	sound energy flux, sound power	P, (P_a)	Sound energy transferred in a certain time interval, divided by the duration of that interval	
7-16.1	sound intensity	I, J	For unidirectional sound energy flux, sound energy flux through an area normal to the direction of propagation divided by that area	
7-17.1 (–)	characteristic impedance of a medium	Z_c	At a point in a medium and for a plane progressive wave, the complex representation of sound pressure divided by the complex representation of particle velocity	For a non-dissipative medium $Z_c = \varrho c$ In these definitions, 7-17.1 to 7-19.1, the quantities entering the numerators and denominators are here assumed to be sinusoidal. $Z_a = \frac{Z_s}{S}$ $Z_m = SZ_s$ where S is the area of the surface considered
7-17.2 (7-17.1)	specific acoustic impedance	Z_s	At a surface, the complex representation of sound pressure divided by the complex representation of particle velocity	
7-18.1	acoustic impedance	Z_a	At a surface, the complex representation of sound pressure divided by the complex representation of volume flow rate	

7. Acoustics (continued)

Units
7-13.a . . . 7-18.a

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	Remarks
7-13.a	metre per second	m/s			
7-14.a	joule per cubic metre	J/m^3			
7-15.a	watt	W			
7-16.a	watt per square metre	W/m^2			
7-17.a	pascal second per metre	$Pa{\cdot}s/m$			
7-18.a	pascal second per metre cubed	$Pa{\cdot}s/m^3$			

Quantities
7-19.1 . . . 7-24.1

7. Acoustics (continued)

Item No.	Quantity	Symbol	Definition	Remarks
7-19.1	mechanical impedance	Z_m	The complex representation of total force at a surface (or at a point) of a mechanical system divided by the complex representation of average particle velocity at that surface (or of particle velocity at that point) in the direction of the force	
7-20.1 (7-21.1)	sound pressure level	L_p	$L_p = \ln (p/p_o)$ $= \ln 10 \cdot \lg (p/p_o)$ where p and p_o are a given sound pressure and a reference pressure, respectively	This quantity is dimensionless The reference pressure must be explicitly stated The subscript p is often omitted, especially when other subscripts are needed See also part II
7-21.1 (7-20.1)	sound power level	L_P, L_W	$L_P = \frac{1}{2} \ln (P/P_o)$ $= \frac{1}{2} \ln 10 \cdot \lg (P/P_o)$ where P and P_o are a given sound power and a reference power, respectively	This quantity is dimensionless The reference power must be explicitly stated See also part II
7-22.1	damping coefficient	δ	If a quantity is a function of time t given by $F(t) = A e^{-\delta t} \sin [\omega (t - t_o)]$ then δ is the damping coefficient	$\tau = 1/\delta$ is the time constant (relaxation time) of the amplitude
7-23.1 (–)	time constant, relaxation time	τ	$\tau = 1/\delta$, where δ is the damping coefficient	
7-24.1 (7-23.1)	logarithmic decrement	Λ	Product of damping coefficient and period	This quantity is dimensionless

7. Acoustics (continued)

Units
7-19.a . . . 7-24.a

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	Remarks
7-19.a	newton second per metre	N·s/m			
7-20.a	decibel	dB	1 dB is the sound pressure level when 20 lg $(p/p_0) = 1$		The numerical value of L_p expressed in decibels is given by 20 lg (p/p_0) See also the Introduction, "Remark on level difference"
7-21.a	decibel	dB	1 dB is the sound power level when 10 lg $(P/P_0) = 1$		The numerical value of L_P expressed in decibels is given by 10 lg (P/P_0) See also the Introduction, "Remark on level difference"
7-22.a	reciprocal second, second to the power minus one	s^{-1}			
7-22.b	neper per second	Np/s			
7-23.a	second	s			
7-24.a	neper	Np			See the Introduction, "Remark on level difference"

Quantities
7-25.1 . . . 7-28.1

7. Acoustics (continued)

Item No.	Quantity	Symbol	Definition	Remarks
7-25.1 (7-24.1)	attenuation coefficient	α	If a quantity is a function of distance x given by $F(x) = A\mathrm{e}^{-\alpha x}\cos[\beta(x - x_0)]$ then α is the attenuation coefficient and β is the phase coefficient	The quantity $l = 1/\alpha$ is called the attenuation length
7-25.2 (7-24.2)	phase coefficient	β		The quantity $\beta\,(x - x_0)$ is called the phase
7-25.3 (7-24.3)	propagation coefficient	γ	$\gamma = \alpha + \mathrm{j}\beta$	
7-26.1 (7-25.1)	dissipation coefficient	δ, (ψ)	Ratio of the sound energy flux dissipated to the incident sound energy flux	These quantities are dimensionless
7-26.2 (7-25.2)	reflection coefficient	r, ϱ	Ratio of the sound energy flux reflected to the incident sound energy flux	
7-26.3 (7-25.3)	transmission coefficient	τ	Ratio of the sound energy flux transmitted to the incident sound energy flux	$\delta + \varrho + \tau = 1$
7-26.4 (7-25.4)	acoustic absorption coefficient	α, (α_a)	$\alpha = \delta + \tau$	
7-27.1 (7-26.1)	sound reduction index, sound transmission loss	R	$R = \frac{1}{2}\ln(1/\tau)$ $= \frac{1}{2}\ln 10 \cdot \lg(1/\tau)$ where τ is the transmission coefficient	This quantity is dimensionless
7-28.1 (7-27.1)	equivalent absorption area of a surface or object	A	The equivalent absorption area of a surface or object in a diffuse sound field is that area of a surface having the acoustic absorption coefficient equal to 1, which, if diffraction effects are neglected, would, in the same diffuse sound field, absorb the same power	