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ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 31

PART I

BASIC QUANTITIES AND UNITS OF THE SI

2nd EDITION

December 1965

This second edition supersedes the first edition.

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Brief History

The Technical Committee ISO/TC 12, *Quantities, Units, Symbols, Conversion Factors and Conversion Tables,* was formed by the ISO for the purpose of arriving at an agreement on 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. The Committee was also instructed to establish conversion factors between the various units and to draw up conversion tables based on these factors.

The Danish Standards Association was commissioned by the ISO to act as Secretatiat of the ISO/TC 12.

The Secretariat of the Technical Committee prepared four successive proposals which were considered by the Committee, by correspondence and at three meetings, held in Copenhagen in 1952, 1953 and 1955.

The fourth proposal (document ISO/TC 12 (Secretariat—51) 131) was circulated in January 1955 and adopted by the Technical Committee, by correspondence and at the meeting in June 1955, as Draft ISO Recommendation.
It should be noted that the following international organizations received the various proposals and participated in the discussions of the Technical Committee at its three meetings:

Comité International des Poids et Mesures,
International Electrotechnical Commission,
International Union of Pure and Applied Physics,
International Union of Pure and Applied Chemistry,
Comité International Provisoire de Métrologie Légale.

The Draft ISO Recommendation was submitted on 25th November 1955 to all the ISO Member Bodies (37 at that time), and approval was obtained by a majority.

The following 27 Member Bodies approved the Draft:

Australia	India	Roumania
Austria	Israel	Spain
Belgium	Italy	Sweden
Bulgaria	Japan	Switzerland
Czechoslovakia	Netherlands	Turkey
Denmark	Norway	Union of South Africa
France	Pakistan	United Kingdom
Germany	Poland	U.S.A.
Hungary	Portugal	Yugoslavia

The following 3 Member Bodies stated that they had no objection to the Draft being approved:

Greece
Ireland
Mexico

The U.S.S.R. failed to approve the Draft because of objections of principle to its form.
Finland failed to approve the Draft because of objections to certain items.

The Secretariat of ISO/TC 12 made some editorial amendments in the Draft in compliance with comments made by various Member Bodies.

The revised Draft was submitted to the ISO Council Members who, in November 1956, decided, by correspondance, to accept it as an ISO RECOMMENDATION.

Brief history relating to 2nd edition

When drafting some of the other parts of ISO Recommendation ISO/R 31, the Secretariat of Technical Committee ISO/TC 12 found it necessary to modify points 1–1.1, 1–2.1, 1–8.1 and 1–9.1 in Part I of this ISO Recommendation and to delete point 1–7.1.

A Draft Revision, drawn up accordingly, was adopted by the Technical Committee in 1960. In September of the same year, this Draft was circulated to all the ISO Member Bodies and was approved by 27 votes to one (Belgium). These modifications were not submitted immediately to the Council for publication as it was considered preferable to prepare a new, complete edition of Part I incorporating the new definitions adopted by the Conférence Générale des Poids et Mesures concerning the metre (1960) and the litre (1964), as well as the new definition of the yard adopted by the USA (1959) and the United Kingdom (1963).

The Draft Revision of ISO Recommendation R/31, Part I, thus completed, was then submitted by correspondence to the ISO Council which decided, in December 1965, to accept it.

Introduction

General remarks

This document, containing the tables:

0. Basic units of the International System of Units
1. Quantities and units of space and time,

is the first part of a more comprehensive publication dealing also with quantities and units within the fields of

Periodic and related Phenomena
Mechanics
Heat
Electricity and Magnetism
Light and related Electromagnetic Radiations
Acoustics
Physical Chemistry and Molecular Physics
Atomic and Nuclear Physics
Nuclear Reactions and Ionizing Radiations

and also

Mathematical Signs and Symbols to be used in Physical Sciences and Technology.

The purpose of this series of documents is to give recommendations for standardization and also to give information, e.g. on the conversion from units in common use (but not always recommended) to recommended units.

Arrangement of the tables

Table 0 contains the basic quantities and units of the International System of Units together with the corresponding international symbols and definitions of the units.

Table 1 is divided into a left-hand side and a right-hand side.

The left-hand side contains the most important quantities of space and time, together with their symbols and in some cases their definitions. The definitions are given merely for identification; they are not intended to be complete definitions. For length, time and various other quantities that are identical with elementary concepts of daily life, no definition is given. The vectorial or tensorial character of certain quantities is not dealt with.

The right-hand side contains the units for the quantities together with their international symbols (or, in certain cases, abbreviations for their names), and their definitions. Where several units are given for one and the same quantity they are arranged in the following order:

SI units (units of the International System of Units)
CGS units
Technical units (metre, kilogramme-force, second units)[1])
Other metric units
FPS units (foot, pound, second units)
British technical units (foot, pound-force, second units)
Other units.

The SI units are placed first.

The SI units and their decimal multiples and submultiples are particularly recommended.

Decimal multiples and submultiples of units are usually not included except when they have a special name (e.g. in the case of are, tonne, ångström etc.).

[1]) This name refers to the system derived from the metre, the second and the force which gives to a mass of 1 kg an acceleration of 9.806 65 m/s^2. The name is not intended to indicate that this system is specially recommended for technical (or other) purposes.

Symbols for Quantities

These symbols are to be printed in italic (sloping) type. Where several symbols are given for one quantity, and no special distinction is made, they are on an equal footing, for instance α, β, γ... etc. for plane angle. If one symbol is used in certain fields and another symbol is used in others, a remark is inserted in the column "Remarks", for instance the symbols ν and f for frequency. When a preferred symbol and a reserve symbol are given, the reserve symbol is in parentheses.
Capital letters may be used as variants for small letters, and vice versa, if no ambiguity is to be feared. For example, instead of d_i and d_e for internal and external diameter, it is permissible to write d and D.

Symbols for Units

Where international symbols for units exist these are given in the appropriate column of the table. These symbols should be strictly observed. They should be printed in roman (upright) type, should remain unaltered in the plural, and should be written without a final full stop (period).
Where symbols for units are combined in a product this process of combination may be indicated by a dot in the following manner: N·m
Other ways of indicating this are: N m, N.m
Where symbols for units are combined in a quotient this process of combination may be indicated by a solidus in the following manner: kg/m³
Other ways of indicating this are: $\frac{\text{kg}}{\text{m}^3}$, kg m^{-3}, kg·m^{-3}, kg.m^{-3}

In no case should more than one solidus be included in such a combination unless parentheses be inserted to avoid all ambiguity. In complicated cases, it is recommended that negative powers or parentheses should be used.

Abbreviations for Names of Units

In cases where no internationally adopted symbols exist for a unit, an abbreviation for the name of the unit is in general given in the column where the name of the unit is found. This abbreviation is given to facilitate the presentation of the table. It relates to the name of the unit in the language used. Its presence does not imply that the abbreviation is accepted internationally. These abbreviations are printed in roman (upright) type. They are in most cases followed by a full stop, but this is not an invariable rule.

Sometimes, even when an international symbol for the unit exists, an abbreviation for the name of the unit is also given for information. In most cases, the information is given in the "Remarks" column.

Number of figures in numerical statements

All numbers in the column "Definition" are exact.

In the column "Conversion factors" some of the conversion factors on which the calculation of others is based are printed in heavy type. These are normally given in 7 significant figures. When they are exact and contain 7 or fewer figures the word "exactly" is added, but when they can be terminated after more than 7 figures they may be given in full. If the conversion factors are derived from experiment they are given to the precision 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 7 figures, the factor is usually rounded off to 7 significant figures.

The other conversion factors are printed in ordinary type. They are given to not more than 6 significant figures; if they are exactly known and contain 6 or fewer figures the word "exactly" is added.

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

0. Basic Units of the International System of Units [1])

Item No.	Quantity	Name of unit	International symbols	Definition of unit	Remarks
0-1	length	**metre**	m	The metre is the unit of length defined under that name by the Conférence Générale des Poids et Mesures.	For details, see page 12
0-2	mass	**kilogramme**	kg	The kilogramme is the unit of mass defined under that name by the Conférence Générale des Poids et Mesures.	For details, see page 12
0-3	time	**second**	s	The second is the unit of time defined under that name by the Conférence Générale des Poids et Mesures.	For details, see page 12
0-4	electric current	**ampere**	A	The ampere is the unit of electric current defined under that name by the Conférence Générale des Poids et Mesures.	For details, see page 12
0-5	thermodynamic temperature	**degree Kelvin**	°K	The degree Kelvin is the unit of thermodynamic temperature defined under that name by the Conférence Générale des Poids et Mesures.	For details, see page 13 For further information about temperature units and scales, see also Part IV: Heat.
0-6	luminous intensity	**candela**	cd	The candela is the unit of luminous intensity defined under that name by the Conférence Générale des Poids et Mesures.	For details, see page 13

[1]) The 11th Conférence Générale des Poids et Mesures (1960) adopted Resolution 12 as follows:

"La Onzième Conférence Générale des Poids et Mesures,

considérant

la résolution 6 de la Dixième Conférence Générale des Poids et Mesures par laquelle elle a adopté les six unités devant servir de base à l'établissement d'un système pratique de mesure pour les relations internationales:

longueur	mètre	m
masse	kilogramme	kg
temps	seconde	s
intensité de courant électrique	ampère	A
température thermodynamique	degré Kelvin	°K
intensité lumineuse	candela	cd

.....

décide:

1° le système fondé sur les six unités de base ci-dessus est désigné sous le nom de Système International d'Unités;
2° l'abréviation internationale du nom de ce système est: SI
....."

Quantities
1-1.1 . . . 1-3.7

1. Space and Time

Item No.	Quantity	Symbol	Definition[1])	Remarks
1-1.1	angle (plane angle)	$\alpha, \beta, \gamma, \vartheta, \theta, \varphi$ etc.	The angle between two half-lines terminating at the same point is defined as the ratio of the arc cut out on a circle (with its centre at that point) to the radius of the circle.	In this definition, which is generally used in the physical sciences and technology, angle is defined as a dimensionless quantity.
1-2.1	solid angle	Ω, ω	The solid angle of a cone is defined as the ratio of the area cut out on a spherical surface (with its centre at the apex of that cone) to the square of the radius of the sphere.	In this definition, which is generally used in the physical sciences and technology, solid angle is defined as a dimensionless quantity.
1-3.1	length	l		
1-3.2	breadth	b		
1-3.3	height	h		
1-3.4	thickness	d, δ		
1-3.5	radius	r		
1-3.6	diameter	d		
1-3.7	length of path	s		

1) The statements in this column are given merely for identification and they are not intended to be complete definitions.

1. Space and Time

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
1-1.a	radian	rad	1 rad is the angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.		The radian is used here instead of the pure number 1.
1-1.b	right angle	....	$1\,\llcorner = \frac{\pi}{2}$ rad	$1\,\llcorner = 1.570\,796$ rad	
1-1.c	grade	....^{g}	$1^{g} = \frac{1}{100}\,\llcorner$	$1^{g} = 0.015\,708\,0$ rad	
1-1.d	degree	....°	$1° = \frac{1}{90}\,\llcorner$	$1° = 0.017\,453\,3$ rad	When using decimal fractions of the degree (or other units of angle), the symbolic abbreviation should be placed after the figures. Example: 15.27°
1-1.e	minute	....′	$1' = \frac{1}{60}°$		
1-1.f	second	....″	$1'' = \frac{1}{60}'$		
1-2.a	steradian	sr	1 sr is the solid angle which, having its vertex in the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.		The steradian is used here instead of the pure number 1.
1-3.a	**metre**	m	The metre is the unit of length defined under that name by the Conférence Générale des Poids et Mesures.		For details, see page 12
1-3.b	micrometre (or micron)	µm (or µ)	1 µm = 10^{-6} m		The designation µm is preferred.
1-3.c	ångström	Å	1 Å = 10^{-10} m	1 Å = 10^{-10} m (exactly)	
1-3.f	yard	yd	1 yd = 0.9144 m	1 yd = 0.9144 m (exactly)	This definition was adopted legally by the United States in 1959 (Announcement U. S. Dep. of Commerce, Nat. Bur. Standards, F. R. Doc. 59-5442 d.d. June 30, 1959) and by the United Kingdom in 1963 (Weights and Measures Act, 1963). An exception is made for the U. S. Survey foot, see remark 1-3. g.

1. Space and Time (continued)

Item No.	Quantity	Symbol	Definition	Remarks
1-4.1	area	*A, (S)*		

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
1-3.g	foot	ft	3 ft = 1 yd	1 ft = 0.3048 m (exactly)	The U. S. Survey foot, used by the U. S. Coast and Geodetic Survey, is defined as 1 U. S. Survey foot $= \frac{1200}{3937}$ m
1-3.h	inch	in	12 in = 1 ft	1 in = 25.4 mm (exactly)	The expression "mil" is sometimes used to denote the "milli-inch".
1-3.i	rod, pole or perch		1 rod, pole or perch = 5½ yd	1 rod, pole or perch = 5.0292 m (exactly)	
1-3.j	chain		1 chain = 22 yd	1 chain = 20.1168 m (exactly)	100 links = 1 chain
1-3.k	furlong		1 furlong = 220 yd	1 furlong = 201.168 m (exactly)	
1-3.l	mile	mile	1 mile = 1760 yd	1 mile = 1609.344 m (exactly)	The mile, written without qualification, is also known as a statute mile. (See below for "nautical mile").
1-3.m	nautical mile, n mile		1 n mile = 1852 m	1 n mile = 1852 m (exactly)	This definition was adopted by the International Hydrographic Conference, in 1929, the U.K. and the U. S. dissenting. Since 1st July 1954, however, the only country using a different n mile is the U.K. The n mile of the U.K. is defined as 6080 ft exactly. It is therefore 1.000 64 n mile approximately.
1-3.n	fathom		1 fathom = 6 ft	1 fathom = 1.8288 m (exactly)	For marine use.
1-3.o	light year, l. y.		1 light year is the distance traversed in 1 year by electromagnetic waves in free space.	1 l. y. = 9.4605×10^{15} m	
1-3.p	astronomic unit, AU			1 AU = $149\,600 \times 10^6$ m	A full definition of the astronomic unit is given in "Annuaire du Bureau des Longitudes, 1966, page B. 22. This unit is approximately equal to the mean distance between the sun and the earth.
1-3.q	parsec, pc		1 parsec is the distance from which 1 astronomic unit appears under the parallax angle of 1 second.	1 pc = **206 264.5** AU = 3.086×10^{16} m = 3.260 l. y.	
1-4.a	square metre	m^2	1 m^2 is the area of a square with sides of length 1 m.		
1-4.b	are	a	1 a is the area of a square with sides of length 10 m.	1 a = 100 m^2	This unit is used solely for agrarian measurements.
1-4.c	square yard	yd^2		1 yd^2 = 0.836 127 m^2	The following abbreviations for the names of the units 1-4.c to 1-4.e are commonly used: sq yd, sq ft, sq in
1-4.d	square foot	ft^2		1 ft^2 = 0.092 903 0 m^2	
1-4.e	square inch	in^2		1 in^2 = 6.4516 cm^2 (exactly)	The expression "circular mil" is sometimes used to designate an area of $\frac{\pi}{4} \cdot 10^{-6}$ in^2
1-4.f	rood		1 rood = 40 square rods = 1210 yd^2	1 rood = 1011.71 m^2	
1-4.g	acre		1 acre = 4 roods = 4840 yd^2	1 acre = 4046.86 m^2	
1-4.h	square mile	$mile^2$		1 $mile^2$ = 2.589 99 km^2 = 640 acres (exactly)	

Item No.	Quantity	Symbol	Definition	Remarks
1-5.1	volume	V, (v)		