S I Units Evolution, Advantages and Applications

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Introduction

The Conference Generale des Poids et Mesures (CGPM) (General Conference on Weights and Measures), was constituted at the "Convention of Metre" held in Paris in 1875 on the use of metre as the unit of length. The CGPM was given the task of controlling the evolution of the metric system and its practical application at the international level. Since its inception, the CGPM has steadily refined and extended the metric system which now goes far beyond the original standards of dimensions and mass. The CGPM at its eleventh meeting in 1960 formally gave the title "Systeme International d' Unites" (International System of Units)—with the abbreviation "SI", to the metric system developed and consolidated in the last decade.

Evolution

The original metric system was based on "metre", "gram" and "second" as the units of length, mass and time respectively. There evolved another system in which the metre was substituted by centimetre for use in the derived units ; this system, perhaps, initiated by scientists, was called the centimetre-gram-second (CGS) system. The CGS system was well accepted by the scientists to whom the microscopic size of the units derived from such small units of length and mass presented little problem. The CGS system, however, to practical technologists offered hardly any attraction, for example, engineers and metallurgists use such units as the kilogram force which is roughly a million times more than the "dyne" the CGS unit of force. It became customary for the scientists to use the CGS system while the practical technologists used what is often referred to as the "metric technical system" ; and thus the link between the scientists and practical technologists has not been as strong as it should and could have been. Furthermore, it was observed that in the metric system used hitherto, a new unit was often created for each situation without regard for other units for the same physical quantity—for example :

(1) for "pressure" the following metric units were devised by different groups.

"atmosphere, bar, barye, cm of water, cm of mercury, kg/cm^2, kg/mm^2, dyne/cm^2. hbar, Newton/m^2, Pascal, Pieze, torr, g/cm^2".

(2) similarly, for "energy" the following units came into being "calories, electron volt, erg, horse-power hour, Joule kilo-watt hour, therme and watt second".

Again, two systems of units were evolved within the very closely related fields of electricity and magnetism—namely the electrostatic units and electromagnetic units. Since these units were either too large or too small, some practical units viz. volt ampere, ohm

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etc. had to be derived. Thus, there arose a confusion of units for quantities of the same kind, but related to each other in a complicated way, and therefore a compendium of factors became necessary to convert from one unit to another.

At the same time, science and technology were becoming more complex and interrelated. By about 1900, practical measurement in metric units began to be based on the "metre", the "kilogram" and the "second" (MKS system). The complex relationship among quantities and the multiplicity of units for the same quantity, led Prof. Giovanni Giorgi to suggest in 1901 that the MKS system of units of mechanics should be linked with the electromagnetic units and proposed adoption of "ampere" as the unit of electric current as the fourth basic unit. This proposal was accepted by International Electro-Technical Commission (IEC) in 1935 and the International Committee on Weight and Measure in 1946 under the authority delegated to it by the CGPM.

The MKS system with the adoption of "ampere" the unit of electric current as the fourth basic unit came to be known as "MSKA" system which was further developed and extended by the CGPM by addition of "kelvin" as the unit of temperature and "candela" as the unit of luminous intensity. At its eleventh meeting in 1960, the CGPM formally gave the title "Systeme International d' Units (International System of Units), with the abbreviation "SI Units". The six basic "SI" units include the metre, the kilogramme, the second, the ampere, the (degree) kelvin and the candela as the units of length, mass, time, electric current, temperature and luminous intensity respectively and are broadly defined below :

Basic SI Units

Physical Quality	*Name of Unit*	*Unit Symbol*	*Definition*
Length	metre	m	Length equal to 1 650 753.73 wave-lengths in vacuum of the radiation corresponding to the transition between the levels of 2p10 5d5 of the Krypton—86 atom.
Mass	kilogram	kg	Mass equal to the international prototype of kilogram (which is in the custody of the Bureau International des Poids et Measures).
Time	second	s	The duration of 9 192 631 770 period of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.
Electric	ampere	A	The ampere is that constant current which if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section and placed one metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre length.
Thermodynamic Temperature	degree kelvin	°K	The fraction 1/273.16 of the thermodynamic temperature of the triple point of water. **Note :** (i) The degree Celsius (°C) is a unit of the International Practical Temperature Scale on which the thermodynamic temperature of the zero point is 273.15K. (ii) The degree Celsius is equal to kelvin (1°C = 1°K). (iii) The degree Celsius may also be used for expressing a temperature interval.
Luminous Intensity	candela	cd	The luminous intensity, in the perpendicular direction of a surface of 1/600 000 square metre of a black body at the temperature of freezing platinum under a pressure of 101 325 newtons per square metre.

In addition to the six basic units, there are two supplementary units, the "radian" (rd) and "steradian" (sr) for measuring plane and solid angles respectively—these are treated as independent units. However, for measuring plane angles, the unit degrees and grade with their decimal sub-divisions are still recommended to be used particularly when the unit "radian" is not suitable.

In addition to the basic and supplementary units there are a number of derived units some of which have been assigned special names (refer Table 1—Appendix I), and some of which have complex names (refer Table 2—Appendix I). It will be noted from the tables that the expressions for the derived units either with special names or with complex names, are stated in terms of the basic units. However, not all SI derived units are listed in Tables 1 and 2.

It will be apparent from the foregoing that "SI" units are the existing metric system as basic units ; the system is therefore not new. What is refreshingly novel about it is the concept that from six basic units alone, it becomes possible through scientific first principles to derive a unit for any and every other required quantity, i.e. all derived units become related to the basic units. The system is, therefore, a refined and rationalized version of the current metric system.

The ISO Technical Committee ISO/TC 12 drew up the ISO Recommendations R 1000, giving rules for the use of units of the International System of Units and a selection of the decimal multiples end sub-multiples of the "SI" units, quantities, unit, symbols, conversion factors and conversion tables. This recommendatioin adopted in 1967 and issued in March 1968, was approved by most ISO Member Bodies. ISO Welding Technical Committee ISO/TC 44 at its seventh Plenary Meeting held in Paris in July 1970 recommended adoption of SI units and all drafts recommended for adoption at this meeting incorporated SI units

Special Features of "SI" System

The following are the main features of the SI system

1. For any quantity there is one and only one SI unit, for example the unit for energy is the "Joule" and the unit for power is the "watt" whether derived from mechanical, electrical, chemical or any other source ; thus eliminating multiplicity of units referred to earlier.
2. For each quantity there is a unique unit differing from the units for other quantities, for example, kilogram is the unit for mass only and newton is the unit for force only—these are not the units for any other quantity.
3. A unique set of symbols and abbreviations are used for the units.
4. All the basic units except the 'kilogram' are defined in terms of physical experiments which can be carried out in the laboratory without recourse to the prototype standard.
5. The factors for obtaining the derived units from the elemental units are always unity, for example : $1N = 1kg. 1m/1s^2$ and $1N. 1m = 1m = 1J = 1W 1s$.
6. The Indo-Arabic system of numbering to the basic 10 is exclusively used, resulting in the multiples and sub-multiples having decimal relationship to the unit.
7. To facilitate working with magnitudes smaller or larger than the SI units, a prefix before the unit can be used—the number of prefixes range from the factor 10^{-18} to 10^{12}, listed in Table 3, Appendix I.
8. The ballast of non-decimal co-efficients (as in the FPS system) has been totally eliminated.
9. It is a coherent system of units, that is one in which the product or quotient of any two unit quantities gives rise to that of the resultant quantity and the units are useful, for example, $1m \times 1m = 1m^2$ is the unit of area and $1m/1s$ is the unit of velocity. This coherence in the system besides being highly important, recommends itself as it simplifies calculations.
10. In contrast to the CGS system, the SI units have relatively large main units for example, "kilogram" and not "gram" for mass and "newton" and not "dyne" for force ; and therefore "SI units to practical technologist" are more convenient. With provisions for multiples and sub-multiples of the coherent units the SI units are of convenient sizes for all applications.

    At the same time, the SI units are closely related (only by powers of 10) with the CGS system which the scientists have been long using—this facilitates collaboration between scientists and practical technologists, this becoming more and more important every day due to modern technological developments.

Applications

It is obvious from Table 3, Appendix I that the number of multiples and sub-multiples which can be used in conjunction with SI units is substantially large. It, therefore, becomes necessary to have some guidance as to which multiples or sub-multiples of SI units are to be used for expressing some quantities, to the exclusion of others. The Technical Committee, ISO/TC 12 Quantities, Units, Symbols, Conversion Factors and Conversion Table having appreciated the complexity of the problem, attempted to resolve this difficulty when issuing the ISO Recommendation R 1000, an extract from which was circulated to the delegates/experts/observers attending Commission I meeting in the Annual Assembly of IIW held in Lausanne in July 1970. ISO Recommendation R 1000 indicates the selection of the decimal multiples and sub-multiples of the SI units. It will be noted that in making the recommendations, two very important and practical principles have been observed :

(i) that any unit which is already internationally recognised and used, shall not be lightly discarded even though the unit in question is a non-SI unit or non-preferred multiple of a SI unit ; and

(ii) to facilitate international communication, the number of preferred multiples and sub-multiples for any particular unit should be so restricted that in any application the "probability of all concerned using the same multiples or sub-multiples would be great"—following from this precept, preference has been expressed for multiples separated by the factor 1000 i.e. of the form $10^{\mp 3n}$ where n is an integer ; it, therefore, becomes apparent that deca (10^1) hecto (10^2), deci (10^{-1}) and centi (10^{-2}) are non-preferred.

A number of important decisions emerge from the above two principles : two examples of such important decisions are : (i) the universally accepted time units namely minute, hour, day, week, month and year will continue to be used and (ii) the division of the circle into 360° and sub-division of the degree into minute and second will continue in trigonometrical purposes while radian will figure in dynamics problems.

Engineers and technologists originally adopted for many quantities, the gravitational units but this was not acceptable to all branches of discipline since acceleration due to gravity "g" is constant only at a particular place. The SI system has abandoned the use of gravitational units and adopted the absolute system which is the most natural system of units.

Despite the many in-built advantages of the SI units the salient features, of which have been broadly described earlier, changing over from metric should be studied and introduced very carefully as it is not unlikely mistakes may be made due to misinterpretation of quantities particularly where there are figures expressed in "kilogram"—which in the metric system, unfortunately, is often used in practice for the designation of mass as well as force. Another factor is that although in principle, ranges of multiples and sub-multiples of SI units have been internationally agreed, there have been sometimes practical differences in the interpretation of all the quantities. However, these are being gradually resolved and a very large measure of standardization has been achieved internationally—refer Table 4, Appendix I lists some of the metric and SI units equivalent and conversion factors.

In the context of this annual assembly and taking due regard to the working of Commission I, it is necessary that SI units and their multiples and sub-multiples which are used for expressing the various physical quantities, should be standardized.

It must be, however, understood that Commission I cannot work in isolation and it will be necessary to liaise with other Commissions in the final acceptance of these recommended units. It should be also noted that in the ISO/TC — 44 Plenary Meeting held in July 1970 some of the SI units together with multiples and sub-multiples for certain quantities were accepted and recommended. The author takes the opportunity of suggesting the standardization of SI units for various other quantities which are listed in Appendix II ; these suggestions may be considered by the Delegates/Experts of Commission I.

Reference and Acknowledgement

1. ISO Recommendation—R 1000, ISO DOC. ref. no. ISO/R 1000- 1969 (E).

2. "Guide to the Use of International System (SI) of Units—Indian Standards Institution, SP : 5- 1969.

APPENDIX I

Table I—Some Derived International System (SI) Units Having Special Names

Physical Quantity	*Name of Unit*	*Unit Symbol*	*Definition*
Force	newton	N = kgm/s^2	That force which, when applied to a body having a mass of one kilogramme, gives it an acceleration of one metre per second squared
Work, Energy Quantity	joule	J = N m	The work done when the point of application of a force of one newton is displaced through a distance of one metre in the direction of the force.
Power	watt	W = J/s	One joule per second
Electric Charge	coulomb	C = A s	The quantity of electricity transported in one second by a current of one ampere
Electric Potential	volt	V = W/A	The difference of potential between two points of conducting wire carrying a constant current of one ampere, when the power dissipated between these points is equal to one watt.
Electric Capacitance	farad	F = A s/V	The capacitance of a capacitor between the plates of which there appears a difference of potential of one volt when it is charged by a quantity of electricity equal to one coulomb.
Electric Resistance	ohm	O = V/A	The resistance between two points of a conductor when a constant difference of potential of one volt, applied between these two points, produces in this conductor a current of one ampere, this conductor not being the source of any electromotive force.
Magnetic Flux	weber	Wb = V s	The flux which, linking a circuit of one turn produces in it an electromotive force of one volt as it is reduced to zero at a uniform rate in one second.
Frequency	hertz	Hz = 1 c/s	The frequency of a periodic phenomenon, the periodic time of which is one second.
Electrical Inductance	henry	H = V s/A	The inductance of a closed circuit in which an electromotive force of one volt is produced when the electric current in the circuit varies uniformly at the rate of one ampere per second.
Luminous Flux	lumen	lm = cd sr	The flux emitted within a unit solid angle of one steradian by a point source having a uniform intensity of one candela.
Illumination	lux	lx = lm/m^2	An illumination of one lumen per square metre.

APPENDIX I

Table 2—Some Derived International System (SI) Units having Complex Names

Physical Quantity	*SI Units*	*Unit Symbols*
Area	square metre	m^2
Volume	cubic metre	m^3
Density (Mass Density)	kilogramme per cubic metre	kg/m^3
Velocity	metre per second	m/s
Angular Velocity	radian per second	rad/s
Acceleration	metre per second squared	m/s^2
Angular Acceleration	radian per second squared	rad/s^2
Pressure	newton per square metre	N/m^2
Surface Tension	newton per metre	N/m
Dynamic Viscosity	newton second per metre squared	$N\,s/m^2$
Kinematic Viscosity Diffusion Coefficient	metre squared per second	m^2/s
Thermal Conductivity	watt per metre degree Kelvin	$W/(m^{\circ}K)$
Electric Field Strength	volt per metre	v/m
Magnetic Flux Density	weber per square metre	Wb/m^2
Magnetic Field Strength	ampere per metre	A/m
Luminance	candela per square metre	cd/m^2
Permeability	henry per metre	H/m
Electric intensity	watt per steradian	W/sr

APPENDIX I

Table 3—Prefixes to be used for decimal multiples and sub-multiples of SI Units

Factor by which the unit is multiplied	Prefix	Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecta	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m

Table 3—*Contd.*

Factor by which the unit is multiplied	Prefix	Symbol
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

"The symbol of a prefix is considered to be combined with the unit symbol to which it is directly attached, forming with it a new unit symbol which can be raised to a positive power and which can be combined with other unit symbols for compound units, for example :

$$1\ \text{cm}^3 = (10^{-2}\text{m})^3 = 10^{-6}\ \text{m}^3$$

$$1\ \mu\text{s}^{-1} = (10^{-6}\ \text{s})^{-1} = 10^{6}\ \text{s}^{-1}$$

$$1\ \text{mm}^2/\text{s} = (10^{-3}\ \text{n})^2/\text{s} = 10^{-6}\ \text{m}^2/\text{s}$$

Compound prefixes shall not be used, for example, nanometre shall be written an "nm" instead of 'mμm' "

APPENDIX I

Table 4 : Some of the Metric & SI Units

EQUIVALENTS AND CONVERSION FACTORS

Sl. No.	*Quality*	*Symbol*	*Metric Units Name of Units*	*Symbol*	*Conversion Factor*	*SI UNITS Name of Units*	*Symbol*
1.	Length	l	angstrom micrometre nautical mile parseco	A μm n mile pc	10^{-10} 10^{-6} 1 852 3.086×10^{16}	metre	m
2.	Area	A	are	a	100	square metre	m^2
3.	Volume	V(v)	litre	l	10^{-3}	cubic	m^3
4.	velocity	u, v, w, c	kilometre per hour knot	km/h kn	1/3.6 0.514 444	metre per second	m/s
5.	acceleration	a	gal	Gal	0.01	metre per second	m/s^2
6.	acceleration of free fall	g	standard acceleration	gn	9.806 65	metre per second	m/s^2

Table 4—*Contd.*

Sl.			*Metric Units*		*Conversion*	*SI UNITS*	
No.	*Quality*	*Symbol*	*Name of Units*	*Symbol*	*Factor*	*Name of Units*	*Symbol*
			PERIODIC AND RELATED PHENOMENA				
7.	frequency	f, v	cycles per second	c/s	1	hertz	Hz
8.	rotational frequency	n	revolution per minute	min^{-1}	1/60	hertz	Hz
9.	wavelength	λ	angstrom	A	10^{-10}	metre	n
			MECHANICS				
10.	mass	m	gram	g	10^{-2}		
			tonne	t	10^3		
			metric carat		2 X 10^{-4}	kilogram	kg
			metric technical units of mass		9.806.65		
11.	density (mass density)	ρ	gram per millilitre	g/ml	999.972	kilogram per cubic metre	kg/m^3
			kilogram per cubic decimetre	kg/dm^3	10^3		
			tonne per cubic metre	t/m^3	10^3		
12.	moment of inertia (dynamic moment of inertia)	I, J	kilogram force metre second squared	kgf.m.s^2	9.806 65	kilogram per metre squared	kgm^2
13.	force	F	dyne	dyn	10^{-5}		
			sthene	sn	10^3	newton	N
			kilogram force	kgf	9.806.65		
			tonne force	tf	9.806.65		
14.	specific weight (weight density)	γ	kilogram force per cubic metre	kgf/m^3	9.806.65		
			kilogram force per cubic decimetre	kgf/dm^3	9.806.65	newton per cubic metre	N/m^3
15.	moment of force	M	dyne centimetre	dyn-cm	10^{-7}		
	bending moment	M	kilogram force centimetre	kgf.cm	9.806 65 $\times 10^{-2}$	newton metre	N.m
	torque, moment of couple	T	kilogram force metre	kgf.m	9.806		

Table 4—*Contd.*

Sl. No.	*Quality*	*Symbol*	*Metric Units* *Name of Units*	*Metric Units* *Symbol*	*Conversion Factor*	*SI UNITS* *Name of Units*	*SI UNITS* *Symbol*
16.	pressure	p	dyne per square centimetre	dyn/cm²	0.1		
	normal stress		microbar	ubar	0.1		
	shear stress		millimetre water	mmH_20	9.806 65		
	Young's modulus (modulus of Elasticity)	E	millimetre mercury	mmHg	133.322		
			torr		133.322		
	shear modulus (modulus of rigidity)	G	kilogram force per square centimetre (technical atmosphere)	kgf/cm² (at)	98 066.5	newton per square metre	N/m²
	bulk modulus (modulus of compression)	K	bar	bar	10^5		
			normal atmosphere	atm	101 325		
			kilogram force millimetre	kgf/mm²	$9.806\ 65 \times 10^6$		
17.	viscosity (dynamic viscosity)	$\eta(\mu)$	centipoise	oP	10^{-3}		
			poise	p	0.1		
			dyne second per square centimetre	dyn.s/cm²	0.1	newton second per square metre	
			kilogram force second per square metre	kgf.s/m²	9.086.65		
18.	kinematic viscosity	v	square centimetre per second	cm²/s	10^{-4}	square metre per second	m²/s
			second stokes	St	10^{-4}		
19.	surface tension	σ (γ)	dyne per centimetre	dyn/cm	10^{-4}	newton per metre	N/m
20.	work energy	A, W	erg	erg	10^{-7}		
		E, W	kilogram force metre	kgf.m	9.806 65		
	potential energy	Ep, U	kilowatt hour	kWh	3.6×10^6		
		V, ϕ	electron volt	eV	1.602×10^{-19}	Joule*	J
	kinetic energy		15°C calorie	cal_{15}	4.185.5		
		Fk,K.T.	IT calorie	calit	4.186. 8		
			thermochemical calorie	cal (ther -mochem	4.184 0		
			thermie	th	$4.185\ 5 \times 10^6$		
			litre atmosphere	1. atm	101.328		

* 1 Joule = 1 newton metre = 1 watt second (1J = 1 N.m — 1 W.s).

Table 4—*Contd.*

Sl. No.	*Quantity*	*Symbol*	*Metric Unit Name of Units*	*Metric Unit Symbol*	*Conversion Factor*	*SI UNITS Name of Units*	*SI UNITS Symbol*
21.	power	p	erg per second kilogram force metre per second metric horse power kilocalorie per hour	erg/s kgf.m/s — kcal/h	10^{-7} 9.806 65 735.499 1.163	Watt	W
			HEAT				
22.	thermodynamic temperature (absolute temperature)	T, θ	degree Rankine	°R	5/9	kelvin	K
23.	customary temperature	t, θ	degree Celsius degree Fahrenheit	°C °F	273.15+t 273.15+(5/9) (t-32)	Kelvin	K
24.	heat. quantity of heat	θ	calorie kilocalorie	cal kcal	4.186 8 4 186 8	Joule	J
25.	heat flow rate	(ϕ) (q)	kilocalorie per hour	kcal/h	1.163	watt or joule per second	W or J/s
26.	density of heat flow rate	q (ϕ)	kilocalorie per second square decimetre	kcal/(s.dm^2)	4.186 × 10^5	watt per square metre	W/m^2
27.	thermal conductivity	λ (k)	calorie per second centimetre degree celsius	cal/s.cm°C	418 68	Watt per metre kelvin	W/(m.k)
28.	coefficient of heat transfer	h,K,U	calorie per second square centimetre degree Celsius	cal/(s.cm^2 °C)	4.186 8 × 10^4	watt per square metre kelvin	W (m^{2}k)
29.	specific heat capacity specific heat capacity at constant pressure specific heat capacity at constant volume	c cp cv	calorie per gram degree kilocalorie per kilogram degree	cal/(g.deg) kcal/(kg.deg)	4 186.8	joule per kilogram kelvin	J/(kg.K)
30.	specific entropy	s	calorie per gram kelvin kilocalorie per kilogram kelvin	cal/(g.k) kcal/(kg.k)	4 186 8	joule per kilogram degree kelvin	J/(kg.K)

Table 4—*Contd.*

Sl. No.	*Quantity*	*Symbol*	*Metric Units* *Name of Units*	*Metric Units* *Symbol*	*Conversion Factor*	*SI UNITS* *Name of Units*	*SI UNITS* *Symbol*
31.	specific internal energy	u(e)	calorie per gram	cal/g	4 186.8		
	specific enthalpy	h(i)	kilocalorie per kilogram	kcal/kg	4 186.8	joule per kilogram	J/kg
	specific free energy	f					
	specific Gibbs function	g					
	specific latent heat	l					

LIGHT

Sl. No.	*Quantity*	*Symbol*	*Metric Units* *Name of Units*	*Metric Units* *Symbol*	*Conversion Factor*	*SI UNITS* *Name of Units*	*SI UNITS* *Symbol*
32.	illumination	E	Phot	Phot	10^4	lux	lx
			lumen per square centimetre	lm/cm²	10^4	lumen per square metre	lm/m²
33.	brightness	L	lambert	—	3 183	candela per square metre	cd/m²

APPENDIX II

SI Units Proposal for Approval

Note : Physical quantities against which asterisk (*) have been shown, have been recommended by ISO/TC 44 for acceptance

PHYSICAL QUANTITIES		*SI UNITS*
Stress	*	newton per millimetre squared.
Gas pressure (regulator inlet and outlet pressures)	*	bar
Gas flowrate (for regulators)	*	cubic metre per hour
Welding hose (size od and id)	*	millimetre
Welding rods (linear measurement across cross-section)	*	millimetres
Brazing alloys, other than powder brazing alloys (linear measurement across cross-section)		millimetre
Electrode (for plasma-arc), dimensions		millimetre
Orifice diameters for welding and cutting nozzles, regulator outlets etc.		millimetre

Appendix II—*Contd.*

PHYSICAL QUANTITIES	*SI UNITS*
Blowpipes/Torches—for welding and cutting, all dimensions.	millimetre
Joint and weld dimensions—all dimensions other than plane angle (some already recommended by ISO/TC 44)	length—millimetre, and for plane angle degree.
Temperature *	degree Celsius
Welding, brazing or cutting speed	millimetre per minute
Flame or gas velocity	metre per second
Capacity of welding and/or cutting blowpipe/torch, expressed in terms of metal thickness.	millimetre
Gas consumption or flowrate through welding/cutting blowpipes or torches (and other fluid flow rates)	litre per hour (for welding blowpipes) and for flow rates less than 1m^3/hr.
	cubic metre per hour (for cutting blowpipes) and for flow rates over 1m^3/hr.
Water flow rate (for torch or similar cooling)	litre per minute
Flame size (length)	millimetre
Current	ampere
Electrical potential	volt
Resistance	ohm
Frequency	hertz
Coating thickness (metalizing)	micro-metre
Cutting kerf width	millimetre
Cutting machine capacity — width	millimetre
— length	millimetre/metre
Water (for cooling) pressure	bar
Standard ambient conditions	as per ISO recommendations.