METRICATION IN SCIENTIFIC PUBLICATIONS

Readers will have noticed that a change has been taking place in the units of measurement used in scientific and technical publications, both in New Zealand and in other English-speaking countries. This change-over — to the system of units known as SI — has been achieved in one step in some journals and gradually in others. It must eventually involve all branches of science and engineering.

SI (which is the abbreviation in many languages of Système International d'Unités) is an extension and refinement of the traditional metric system. It embodies features which make it logically superior to any other system as well as practically more convenient; it is rational, coherent and comprehensive.

The metric system, which has spread to several countries in the aftermath of the French Revolution, began to displace Imperial units in scientific work during the last quarter of the nineteenth century. Its use extended more and more widely, although there are still branches of science where Imperial units have continued to predominate. It is fortunate that, now that the time has come to discard completely the time-honoured traditional units (which are not without their advantages), there is a fully developed international system to take their place. Over the years much thought has been given to extending and improving the metric system, until finally in 1960 the Conférence Générale des Poids et Mesures, the body responsible for maintaining standards of measurements, formally approved SI. Already nearly 30 countries have decided to make it the only legally accepted system, and it is clearly destined to become the universal currency of science and commerce.

A periodical such as the *Journal of Hydrology*, circulating among both scientists and engineers, can play a crucial role in helping to end the confusion and wastefulness (both mental and material) resulting from the present multiplicity of units.

The main features of SI are as follows:

1. There are six basic units (see list), the metre and kilogram taking the place of the centimetre and gram of the old metric system.

* This article is based on material compiled and published by the U.K. Royal Society Conference of Editors.

2. The unit of force, the newton ($kg\,m\,s^{-2}$), is independent of the Earth's gravitation, and the often confusing introduction of g into equations used in some branches of science and technology is no longer necessary.

3. The unit of energy in all forms is the joule (newton × metre), and of power the joule per second (watt); thus the variously defined calories, together with the kilowatt hour, the B.t.u. and the horsepower are all superseded.

4. 'Electrostatic' and 'electromagnetic' units are replaced by SI electrical units.

5. Multiples of units are normally to be restricted to steps of a thousand, and similarly fractions to steps of a thousandth.

Lists are appended of the basic SI units, of some derived SI units, of compatible units, and also examples of units which run counter to SI — the use of which is accordingly to be actively discouraged. Also listed are the names and symbols of the prefixes representing numerical factors; these are both convenient in obviating the need to write large numbers of zeros or in some instances high powers of 10, and also helpful in establishing familiarity with the numerical framework of modern science.

The *Journal of Hydrology* will continue to publish papers in which Imperial units are used; authors are, however, encouraged to adopt the international system of units. In order to avoid tedious and error-producing conversions from one system of units to another, it is best that work be reported in the units used in the original measurements. Full metrication may therefore have to wait upon the availability of metric equipment and data, although it is hoped that this goal can be achieved with a minimum of delay.

Basic SI units

Physical quantity	*Name of unit*	*Symbol for unit*
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	degree Kelvin	°K
luminous intensity	candela	cd

Symbols for units do not take a plural form.

Supplementary units

Physical quantity	*Name of unit*	*Symbol for unit*
plane angle	radian	rad
solid angle	steradian	sr

These units are dimensionless.

Derived SI units with special names

Physical quantity	*Name of unit*	*Symbol for unit*	*Definition of unit*
energy	joule	J	$kg\ m^2\ s^{-2}$
force	newton	N	$kg\ m\ s^{-2} = J\ m^{-1}$
power	watt	W	$kg\ m^2\ s^{-3} = J\ s^{-1}$
electric charge	coulomb	C	A s
electric potential difference	volt	V	$kg\ m^2\ s^{-3}\ A^{-1} = J\ A^{-1}\ s^{-1}$
electric resistance	ohm	Ω	$kg\ m^2\ s^{-3}\ A^{-2} = V\ A^{-1}$
electric capacitance	farad	F	$A^2\ s^4\ kg^{-1}\ m^{-2} = A\ s\ V^{-1}$
magnetic flux	weber	Wb	$kg\ m^2\ s^{-2}\ A^{-1} = V\ s$
inductance	henry	H	$kg\ m^2\ s^{-2}\ A^{-2} = V\ s\ A^{-1}$
magnetic flux density	tesla	T	$kg\ s^{-2}\ A^{-1} = V\ s\ m^{-2}$
luminous flux	lumen	lm	cd sr
illumination	lux	lx	$cd\ sr\ m^{-2}$
frequency	hertz	Hz	cycle per second
customary temp.	deg. Celsius	°C	°C = °K − 273.15

Fractions and Multiples

Fraction	*Prefix*	*Symbol*	*Multiple*	*Prefix*	*Symbol*
10^{-1}	deci	d *	10	deka	da*
10^{-2}	centi	c *	10^2	hecto	h *
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	μ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f			
10^{-18}	atto	a			

* To be restricted to instances where there is a strongly felt need.

Compound prefixes should not be used, for example 10^{-9} metre is represented by 1 nm, not 1 mμm.

The attaching of a prefix to a unit in effect constitutes a new unit, for example $1\ km^2 = 1\ (km)^2 = 10^6\ m^2$, not $1\ k(m^2) = 10^3\ m^2$.

Where possible any numerical prefix should appear in the numerator of an expression, for example $kg\ m^{-1}$, not $g\ mm^{-1}$.

Examples of units contrary to SI, with their equivalents

Physical quantity	*Unit*	*Equivalent*
length	millimicron	10^{-9} m = nm
	inch	25.4 mm
	foot	0.3048 m
	yard	0.9144 m
	chain	20.12 m
	mile	1.609 km
area	square inch	645.2 mm^2
	square foot	0.0929 m^2
	square yard	0.8361 m^2
	acre	4047 m^2
	square mile	2.59 km^2
volume	cubic inch	1.639×10^{-5} m^3
	cubic foot	0.02832 m^3
	cubic yard	0.7645 m^3
	UK gallon	0.004546 m^3
	acre-inch	102.8 m^3
	acre-foot	1233 m^3
velocity	foot/second	0.3048 m s^{-1}
	mile/hour	0.447 m s^{-1}
mass	pound	0.4536 kg
	UK ton	1016 kg
density	pound/cubic foot	16.02 kg m^{-3}
force	dyne	10^{-5} N
	poundal	0.1382 N
	pound-force	4.448 N
	kilogram-force	9.807 N
pressure	atmosphere	101.3 kN m^{-2}
	pound (f)/sq.in.	6895 N m^{-2}
energy	erg	10^{-7} J
	foot-poundal	0.04214 J
	foot pound (f)	1.356 J
	calorie (thermochemical)	4.184 J
	B.t.u.	1055 J
	kilowatt hour	3.60 MJ
power	horsepower	745.7 W
temperature	degree Fahrenheit	°F = °C(9/5) + 32
sediment	UK ton/day	0.01176 kg s^{-1}
flow	million UK gallons/day	0.05262 m^3 s^{-1}
	cusec	0.02832 m^3 s^{-1}
	cusec/square mile	0.01093 m^3 s^{-1} km^{-2}

Examples of derived SI units used in hydrology

Physical quantity	*Usual symbol for quantity*	*SI unit*
mass precipitation	P	mm
precipitation intensity	i	mm h^{-1}
potential evapotranspiration	E_t	mm
mass infiltration	F	mm
infiltration rate	f	mm h^{-1}
soil moisture content	M_s	kg kg^{-1}. m^3 m^{-3}
run-off	Q	m^3, mm depth
discharge	q	m^3 s^{-1}

Examples of units to be allowed in conjunction with SI

Physical quantity	*Name of unit*	*Symbol of unit*	*Definition of unit*
area	hectare	ha	10^4 m^2
volume	litre	l	10^{-3} $m^3 = dm^3$
pressure	bar	bar	10^5 N m^{-2}
mass	tonne	t	10^3 kg = Mg

The common units of time (for example hour, year) will persist, and also — in appropriate context — the angular degree.

Until such time as a new name may be adopted for the kilogram as the basic unit of mass, the gram will often be used, both as an elementary unit (to avoid the absurdity of mkg) and in association with numerical prefixes, for example, μg.