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# SI-UNITS AND GLACIOLOGY

The system of units known as Système International d'Unités, abbreviated SI, is an extension and refinement of the traditional metric system. It provides a rational, coherent, comprehensive system of units and is rapidly becoming accepted as the form of the metric system to be legally adopted. Following its adoption by the Conférence Générale des Poids et Mesures in 1960, nearly thirty countries have decided to make it the only legally accepted system and it is clearly destined to become the universally used system in science, industry and commerce.

In view of this it is desirable that learned journals should encourage its adoption, and accordingly the *Journal of Glaciology* will, in future, recommend that numerical data should be expressed in SI-units or in other units which are approved for use in conjunction with SI. Authors writing papers for the *Journal* should attempt to use such units, and where any other units have to be employed, the SI equivalent should be given. In adopting this policy the *Journal* is simply up-dating its long-standing rule that metric units should be employed whenever possible, and that where other units have to be used metric equivalents should be given.

The main features of SI are as follows:

1. There are six basic units, as given in Table I, the metre and the kilogramme replacing the centimetre and gramme of the old c.g.s. metric system.
2. The unit of force is the newton ($1\ \text{N} \equiv 1\ \text{kg m s}^{-2}$) and is independent of the Earth's gravitation. The kilogramme force should not be used.
3. The unit of energy (including heat) is the joule ($1\ \text{J} \equiv 1\ \text{N m}$) and of power is the watt ($1\ \text{W} \equiv 1\ \text{J s}^{-1}$). The various different calories are therefore not to be used.
4. Electrical units are as in the so-called M.K.S.A. system, which replaces the "electrostatic", "electromagnetic" and "Gaussian" units.
5. Multiples of units are normally to be restricted to steps of a thousand, and fractions to steps of a thousandth. The symbols to be used for fractions and multiples are given in Table II. Compound prefixes should not be used, and where possible the numerical prefix should appear in the numerator of an expression.

TABLE I. BASIC SI-UNITS

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

TABLE II. 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 | | | |

* The bracketed fractions and multiples should not be used unless there is a strongly felt need.

In addition to the basic units, there are two supplementary units, the radian for angle (symbol rad) and the steradian for solid angle (symbol sr). There are also several derived SI units that are given separate names. These are listed in Table III.

TABLE III. DERIVED SI UNITS WITH SPECIAL NAMES

| *Physical quantity* | *Name of unit* | *Symbol* | *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 | cycles per second |
| customary temperature | degree Celsius | °C | $t(°C) = T(°K) - 273.15$ |
| temperature interval | degree | deg | No specification of C or K necessary |

There are also a number of existing units that have been approved for continued use alongside the SI units. These include several of importance in glaciology which are listed in Table IV.

TABLE IV. UNITS ALLOWED IN CONJUNCTION WITH SI

| *Physical quantity* | *Name of unit* | *Symbol* | *SI equivalent* |
|---|---|---|---|
| time | hour | h | 3 600 s |
| time | day | d | 86 400 s = 24 h |
| time | year | a | In terms of Earth's rotation round sun |
| volume | litre* | l | $10^{-3}\,m^3 = dm^3$ |
| pressure | bar | bar | $10^5\,N\,m^{-2}$ |
| mass | tonne | t | $10^3\,kg = Mg$ |
| kinematic viscosity | stokes | St | $10^{-4}\,m^2\,s^{-1}$ |
| dynamic viscosity | poise | P | $10^{-1}\,kg\,m^{-1}\,s^{-1}$ |
| magnetic flux density | gauss | G | $10^{-4}\,T$ |
| radioactivity | curie | Ci | $37 \times 10^9\,s^{-1}$ |
| angle | degree | ° | $\pi/180$ rad |
| energy | electronvolt | eV | $1.6021 \times 10^{-19}\,J$ |

* The litre should not be used in very accurate work.

The main changes in glaciological practice will be (a) the dropping of the calorie, and its derived units including the Langley, in radiation work and their replacement by the joule and units derived from it (1 cal (I.T.) = 4.1868 J, 1 Langley = 41.868 kJ $m^{-2}$); (b) the use of mm or m for length measurement, thus the density of ice would be expressed for preference in Mg $m^{-3}$ rather than g $cm^{-3}$ (the two units being identical in magnitude); (c) stresses and pressures ought to be measured in multiples of N $m^{-2}$ or in bars, and not in kg $cm^{-2}$, atmospheres or mm of Hg.

A number of examples of appropriate units are given in Table V.

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TABLE V. EXAMPLES OF GLACIOLOGICAL QUANTITIES AND APPROPRIATE UNITS

| *Glaciological quantity* | *SI unit* | *Examples of other allowed units* | *Units not allowed* |
|---|---|---|---|
| ablation, accumulation | m $H_2O$ | mm $H_2O$ | |
| mass accumulation | kg $m^{-2}$ | | g $cm^{-2}$ (= 10 kg $m^{-2}$) |
| ice velocity | m $s^{-1}$ | mm $s^{-1}$, $\mu$m $s^{-1}$, m $d^{-1}$, m $a^{-1}$ | |
| discharge | $m^3$ $s^{-1}$ | | |
| heat flux density | W $m^{-2}$ | kW $m^{-2}$ | kcal $cm^{-2}$ $year^{-1}$ (= 1.324 W $m^{-2}$)<br>Langley $h^{-1}$ (= 11.63 W $m^{-2}$)<br>Langley $s^{-1}$ (= 41.868 kW $m^{-2}$) |
| thermal conductivity | W $m^{-1}$ $deg^{-1}$ | | cal $cm^{-1}$ $s^{-1}$ $deg^{-1}$ (= 4.1868 W $m^{-1}$ $deg^{-1}$) |
| thermal diffusivity | $m^2$ $s^{-1}$ | | |
| specific heat capacity | J $kg^{-1}$ $deg^{-1}$ | kJ $kg^{-1}$ $deg^{-1}$ | cal $g^{-1}$ $deg^{-1}$ (= 4.1868 kJ $kg^{-1}$ $deg^{-1}$) |
| integrated heat flux | J $m^{-2}$ | kJ $m^{-2}$ | Langley (= 41.868 kJ $m^{-2}$) |
| stress | N $m^{-2}$ | kN $m^{-2}$, bar | kg $cm^{-2}$ (= 98 066.5 N $m^{-2}$) |
| pressure | N $m^{-2}$ | bar | mm Hg (= 133.322 N $m^{-2}$) |
| density | kg $m^{-3}$ | Mg $m^{-3}$ | g $cm^{-3}$ (= Mg $m^{-3}$) |

The recommendations with regard to units made in this note are consistent with the general recommendations regarding symbols, units and nomenclature made in *Journal of Glaciology*, Vol. 6, No. 48, 1967, p. 779, and should be considered as a further specification of the practice of the *Journal*.