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S.I. UNITS AND THEIR USE AT THE FIRE RESEARCH STATION

by

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FIRE RESEARCH STATION

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SUMMARY

The note explains the S.I. units and gives a list of those which are to be commonly used by the Fire Research Station, with other units that at present may be used as well. A list of conversion factors is also given.

KEY WORDS: Units.

MINISTRY OF TECHNOLOGY AND FIRE OFFICES' COMMITTEE
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INTRODUCTION

Since industry and editors of journals are now beginning to change to S.I. units, it has been decided to use these units at the Fire Research Station, beginning on 1st April, 1970.

The purpose of this note is to give some help in the change from C.G.S. and British units to S.I. units. A list of S.I. units (or other permissible units) likely to be in constant use is given together with conversion factors from S.I. to British and C.G.S. units.

S.I. UNITS

The Système International d' Unités was introduced to rationalize the metric system and is based on six primary units, namely:

Quantity	Unit	Symbol
length	metre	m
mass	kilogramme	kg
time	second	s
electric current	ampère	A
temperature	kelvin	k
luminous intensity	candela	cd

The names of multiples and sub-multiples of the basic units are formed except for the kilogramme by means of prefixes which are the same irrespective of the basic units to which they are applied.

Factor by which the unit is multiplied	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Multiplying prefixes are printed immediately adjacent to the unit symbols with which they are associated. The multiplication of symbols is indicated by placing them with only a small gap between them

e.g. 1kN m

CHOICE OF PREFIX

On the choice of prefix, the pamphlet 'Changing to the metric system' makes the following recommendations.

1) The use of prefixes representing 10 raised to a power which is a multiple of ± 3 is recommended. The prefixes hecto, deca, deci and centi should be limited so far as possible to uses where the recommended prefixes are very inconvenient.

2) When expressing a quantity by a numerical value and a certain unit it has been found suitable, in most applications, to use prefixes resulting in numerical values between 0.1 and 1000. To do so, it is occasionally necessary to use prefixes other than the recommended ones. It is sometimes convenient when tabulating values to use headings such as $10^3 m^2$ to simplify the table.

3) It is recommended that prefixes should be used in the numerator only (whenever it is practicable to do so).

BASIC S.I. UNIT

Candela (cd), the unit of luminous intensity. The candela is 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.

DERIVED UNITS HAVING SPECIAL NAMES

Hertz (Hz), the unit of frequency. The number of repetitions of a regular occurrence in one second.

Lumen (lm), the unit of luminous flux. The flux emitted within unit solid angle of 1 steradian by a point source having a uniform intensity of 1 candela (cd).

Lux (lx), the unit of illumination. An illumination of 1 lumen per square metre.

Newton (N), the unit of force, is the force required to produce, in a mass of 1 kilogramme, an acceleration of 1 metre per second per second.

Pascal is the name given to the newton per square metre in some countries.

GENERAL PRINCIPLES

As S.I. units are comparatively new, it has been decided that, in papers at present, it would be best to give the S.I. unit with the British unit in brackets, the first time that particular S.I. unit appears in the text. Tables and graphs should give both S.I. and British units.

REFERENCE

(1) ANDERTON, P. and BIGG, P. H. Changing to the metric system. Ministry of Technology National Physical Laboratory. London, 1969, H.M. Stationery Office.

Table 1

Units to be used at the Fire Research Station

	S.I. or recommended multiple unit	Other permissible units
Length	km	
	m	cm[f]
	mm	
Area	km^2	
	m^2	ha[ϕ] cm^2[f]
	mm^2	
Volume	m^3	cm^3[f]
	mm^3	
Capacity	m^3, mm^3	l, ml
Time	s	min, h
Mass	kg	tonne
	g	
	mg	
Density	kg/m^3	kg/l* g/cm^3[f]

[f] Only to be used where recommended prefixes are very inconvenient

*For accurate measurement.

[ϕ] Hectare

	S.I. or recommended multiple unit	Other permissible units
Velocity	m/s	cm/s[1], km/h
Flow rate		m^3/min, l/s, l/min
Flow rate per unit area		m/min, mm/min
Frequency	Hz	
Force	kN	
	N	
	MN	
Pressure	kN/m^2	
	N/m^2	
Kinematic viscosity	m^2/s	
Dynamic viscosity	Ns/m^2	
Heat	J	
Work	J	

[1] Only to be used where recommended prefixes are very inconvenient.

	S.I. or recommended multiple unit	Other permissible units
Power	W	
Celsius temperature		^{o}C
Thermodynamic temperature	K	^{o}C
Temperature interval[/]	K	^{o}C
Coefficient of linear expansion	$1/K$	$1/^{o}C$
Rate of heating	kW	
	W	
Rate of heating per unit area	kW/m^2	
	W/m^2	
Coefficient of heat transfer Thermal conductance	W/m^2K	$W/m^2\ ^{o}C$
Thermal diffusivity	m^2/s	

[/]The abbreviation 'deg' is commonly used to express a temperature interval, but is now regarded as obsolescent. However it may be used in textual matter e.g. Increase the temperature by 20 degC.

	S.I. or recommended multiple unit	Other permissible units
Specific heat (volume basis)	$J/m^3 K$	$J/m^3 {}^{\circ}C$
Specific heat (mass basis)	J/kg K	J/kg $^{\circ}C$
Plane angle	rad	degree ($^{\circ}$)
Solid angle	sr	
Wave length		$\mathring{A}$, μm
Electric current	A	
Electric potential	V	

Table 2

Conversion factors

Length	1 km	=	0.621	mile
	1 m	=	3.28	ft
	1 mm	=	0.394	in
Area	1 km^2	=	247	acres
		=	1.08×10^7	ft^2
	1 ha	= $10^4 m^2$ =	2.47	acres
	1 m^2	=	10.8	ft^2
	1 mm^2	=	1.55×10^{-3}	in^2
Volume	1 m^3	=	35.3	ft^3
	1 mm^3	=	6.10×10^{-5}	in^3
Capacity	1 l	=	0.220	gal
Mass	1 kg	=	2.20	lb
	1 g	=	0.0353	oz
	1 tonne(t)	=	1×10^3	kg
Density	1 kg/m^3	=	0.0624	lb/ft^3
Fire load	1 kg	=	2.20	lb
Fire load density	1 kg/m^2	=	0.205	lb/ft^2
Velocity	1 km/h	=	0.911	ft/s
	1 m/s	=	3.28	ft/s
Flow rate	1 m^3/min	=	35.3	ft^3/min
	1 l/s	=	13.2	gal/min
	1 l/min	=	0.220	gal/min

Flow rate per unit area	1 mm/min	=	0.0204	gal/ft^2 min
Frequency	1 Hz	=	1	c/s
Force	1 kN	=	0.100	tonf
	1 N	=	0.225	lbf
Pressure	1 kN/m^2	=	20.9	lbf/ft^2
	1 N/m^2	=	1.45×10^{-4}	lbf/in^2
		=	4.01×10^{-3}	in H_2O
Kinematic viscosity	1 m^2/s	=	10.8	ft^2/s
Dynamic viscosity	1 Ns/m^2	=	0.0209	$lbfs/ft^2$
Heat	1 J	=	9.48×10^{-4}	Btu
		=	0.239	cal
Work	1 J	=	0.738	ft lbf
Power	1 W	=	1	J/s
		=	0.239	cal/s
		=	1.34×10^{-3}	hp
Celsius temperature	t^oC	=	$\frac{5}{9}$ (T^oF - 32)	
Temperature interval	K	=	$\frac{9}{5}$ ^oF	
Coefficient of linear expansion	$1/K, (1/^oC)$	=	$\frac{5}{9}$ ^oF	
Rate of heating	1 kW	=	0.948	Btu/s
	1 W	=	3.41	Btu/h
Rate of heating per unit area	1 W/m^2	=	0.317	Btu/ft^2h
		=	2.39×10^{-5}	cal/cm^2s
Coefficient of heat transfer Thermal conductance	1 W/m^2 K	=	0.176	Btu/ft^2 h ^oF
		=	2.39×10^{-5}	cal/cm^2s ^oC

Thermal conductivity	1 W/m K	=	0.578	Btu/ft h °F
		=	2.39×10^{-3}	cal/cm s °C
Thermal diffusivity	1 m^2/s	=	3.875×10^{4}	ft^2/h
Specific heat (Volume basis)	1 J/m^3 K	=	1.49×10^{-5}	Btu/ft^3 °F
		=	2.39×10^{-4}	cal/l °C
Specific heat (Mass basis)	1 J/kg K	=	2.39×10^{-4}	Btu/lb °F
		=	2.39×10^{-4}	cal/g °C
Wave length	Å	=	10^{-10} m = 10^{-1} nm	
	µm	=	10^{-6} m	

METRICATION: LIST OF S.I. UNITS RECOMMENDED FOR USE IN THE FIRE SERVICE

Quantity and basic or derived SI Unit and symbol	Areas of use	Present U.K. Units	Recommended Unit of Measure	Value of U.K. Unit in terms of Recommended Unit
LENGTH metre (m)	Distances Heights of buildings, lengths of ladders, hose, wires and ropes etc.	mile yards feet	kilometre (km) metre (m)	1 mile = 1.609 km 1 yd. = 0.914 m 1 ft. = 0.305 m
	Hose fittings, couplings, circ of ropes, ladder fittings etc.	inches	millimetre (mm)	1 inch = 25.4 mm
AREA square metre (m^2)	Surface areas of floors, walls, ceilings, windows, doors, heating surfaces etc.	square yard or square foot	square metre (m^2)	1 $yd.^2$ = 0.836 m^2 1 $ft.^2$ = 0.093 m^2
	Sectional areas of hose fittings, ladder fittings, rope etc.	square inch	square millimetre (mm^2)	1 $in.^2$ = 645.2 mm^2
	Fields, installations, harbours, etc.	square miles acres	square kilometre (km^2)	1 $mile^2$ = 2.590 km^2
VOLUME cubic metre (m^3)	Volume of buildings, tanks, containers, etc.	cubic foot	cubic metre (m^3)	1 cu.ft. = 0.028 m^3
	Volume of small tanks, air receivers, etc. smaller than 1 m^3	gallon	litre (l) ($10^{-3}m^3$)	1 gallon = 4.546 litres
VOLUME FLOW (m^3/s)	Hydraulics	cubic feet per second	cubic metre per second (m^3/s) cubic metre per minute (m^3/m)	1 $ft.^3/s$ = 0.028 m^3/s
		gallons per minute	litres per second (l/s)	1 gall/min. = 4.546 litres/s

Quantity and basic or derived SI Unit and symbol	Areas of use	Present U.K. Units	Recommended Unit of Measure	Value of U.K. Unit in terms of Recommended Unit
MASS milogramme (kg)	All measurements of weight	tons, cwts, lbs.	kilogramme (kg) tonne (t)	1 lb. = 0.454 kg 1 ton = 1.016 tonne
VELOCITY metre per second (m/s)	Road speeds	miles per hour	kilometre/hour (km/h)	1 mile per hr. = 1.61 kilometre/hour
	Ship speeds	U.K. knot	International knot (kn)	1 U.K. knot = 1.853 km/h 1 International knot = 1.852 km/h
	Fluid velocity Linear velocity of machinery parts Speed of cables ropes, wires	foot/ second	metre/second (m/s)	1 ft./s = 0.305 m/s
ACCELERATION (m/s^2)		foot/ $second^2$	metre/$second^2$ (m/s^2)	1 ft./s^2 = 0.305 m/s^2
PRESSURE (N/m^2)	Normal fluid pressure, e.g. compressed air, oil, steam, water	atmosphere	bar = $10^5 N/m^2$	1 atm = 101.325 kN/m^2 = 1.013 bar
		pounds per square inch		1 $lb.f/in^2$ = 6894.76 N/m^2 = 0.069 bar
	Barometric measures and pressures of small magnitude	inch of mercury	millibar (mbar) (= $10^2 N/m^2$)	1 in.Hg = 33.86 mbar 1 in.Hg = 25.4 mm Hg
HEAT, QUANTITY OF HEAT joule (J)	Thermodynamics	British thermal units	kilojoule (kJ)	1 Btu = 1.055 kJ
HEAT FLOW RATE watt (W)	Thermodynamics	British thermal unit/hour	watt (W)	1 Btu/h = 0.293 W
	Thermodynamics	British thermal unit/	kilowatt (kW)	1 Btu/s = 1.055 kW
SPECIFIC ENERGY, CALORIFIC VALUE, SPECIFIC LATENT HEAT (J/kg)	Thermodynamics	British thermal unit/pound	kilojoule/ kilogramme (kJ/kg)	1 Btu/lb. = 2.326 kJ/ kg

or derived SI Unit and symbol	Areas of use	Present U.K. Units	Unit of Measure	in terms of Recommended Unit
FORCE newton (N)	Machine and structure design	ton force pound force	kilonewton (kN) newton (N)	1 ton f = 9.964 kN 1 lb. f = 4.448 N
ENERGY WORK joule (J) (= 1 N m)	Practical usage	horsepower hour	kilowatt hour (kW h) (= 3.6 MJ)	1 hph = 0.746 kW h
	Thermodynamics	British thermal unit	kilojoule (kJ)	1 Btu = 1.055 kJ
		foot pound force	joule (J)	1 ft. lb. f = 1.356 J
POWER watt (W) (= 1 J/s = 1 N m/s)	Mechanical, electrical or hydraulic power of normal magnitude	horsepower	kilowatt (kW)	1 HP = 0.746 kW
	Very small powers	foot pound force/second	watt	1 ft.lb.f/sec = 1.356 W

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