CIVIL AVIAION DEPARTMENT
Republic of Maldives

MALDIVIAN
CIVIL AVIATION REGULATIONS

MCAR-5
UNITS OF MEASUREMENT TO BE USED IN AIR AND GROUND OPERATIONS

1.LIST OF AMMENDMENTS

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CHAPTER 1 – DEFINITIONS

Refer to MCAR-1

CHAPTER 2 – APPLICABILITY

Introductory Note – This MCAR contains specifications for the use of a standardized system of units of measurement in international civil aviation air and ground operations. This standardized system of units of measurement is based on the International System of Units (SI) and certain nun-SI units considered necessary to meet the specialized requirements of international civil aviation. See Attachment A for details concerning the development of the SI.

2.1 Applicability

The Standards and Recommendations contained in this document shall be applicable to all aspects of international Civil Aviation Air and Ground operations in the Republic of Maldives.

CHAPTER 3 – STANDARD APPLICATION OF UNITS OF MEASUREMENT

3.1 SI Units

3.1.1 The International System of Units developed and maintained by the General Conference of Weights and Measures (CGPM) shall, subject to the provisions of 3.2 and 3.3, be used as the standard system of units of measurement for all aspects of international civil aviation air and ground operations.

3.1.2 Prefixes

The prefixes and symbols listed in Table 3-1 shall be used to form names and symbols of the decimal multiples and sub-multiples of SI units.

Note I – As used herein the term SI unit is meant to include base units and derived units as well as their multiples and sub-multiples.

Note 2 – See Attachment B for guidance on the general application of prefixes

Table 3.1 – SI unit prefixes

Multiplication factor			*Prefix*	*Symbol*
1 000 000 000 000 000 000	=	10^{18}	exa	E
1 000 000 000 000 000	=	10^{15}	peta	P
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}	hecto	h
10	=	10^{1}	deca	da
0.1	=	10^{-1}	deci	d
0.01	=	10^{-2}	centi	c
0.001	=	10^{-3}	milli	m
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

3.2 Non-SI Units

3.2.1 Non-SI units for permanent use with the SI

The non-SI units listed in Table 3-2 shall be used either in lieu of, or in addition to, SI units as primary units of measurement but only as specified in Table 3-4.

3.2.2 Non-SI alternative units permitted for temporary use with the SI

The non-SI units listed in Table 3-3 shall be permitted for temporary use as alternative units of measurement but only for those specific quantities listed in Table 3-4.

3.3 Application of specific units

3.3.1 The application of units of measurement for certain quantities used in international civil aviation air and ground operations shall be in accordance with Table 3-4.

Note – Table 3-4 is intended to provide standardization of units (including prefixes) for those quantities commonly used in air and ground operations. Basic provisions of the ASN shall apply for units to be used for quantities not listed.

3.3.2 It is recommended that means and provisions for design, procedures and training should be established for operations in environments involving the use of standard and non-SI alternatives of specific units of measurement, or the transition between environments using different units, with due consideration to human performance.

Note – Guidance material on human performance can be found in the Human Factors Training Manual (Doc 9683) and Circular 238 (Human Factors Digest No. 6 - Ergonomics).

Table 3-2 – Non-SI units for use with the SI

Specific quantities in Table 3-4 related to	*Unit*	*Symbol*	*Definition (in terms of SI units)*
mass	tonne	t	$1\ t = 10^3\ kg$
plane angle	degree	°	$1° = (\pi/180)$ rad
	minute	'	$1' = (1/60)° = (\pi/10\ 800)$ rad
	second	"	$1'' = (1/60)' = (\pi/648\ 000)$ rad
temperature	degree Celsius	°C	1 unit °C = 1 unit K[a)]
time	minute	min	1 min = 60 s
	hour	h	1 h = 60 min = 3 600 s
	day	d	1 d = 24 h = 86 400 s
	week, month, year	—	
volume	litre	L	$1\ L = 1\ dm^3 = 10^{-3} m^3$

a) See Attachment C, Table C-2 for conversion.

Table 3-3 – No1141 alternative units permitted for temporary use with the SI

Specific quantities in Table 3-4 related to	*Unit*	*Symbol*	*Definition (in terms of SI units)*
distance (long)	nautical mile	NM	1 NM = 1 852 m
distance (vertical)[a)]	foot	ft	1 ft = 0.304 8 m
speed	knot	kt	1 kt = 0.514 444 m/s

a) altitude, elevation, height, vertical speed.

Table 3-4. Standard application of specific units of measurement

Ref. No.	*Quantity*	*Primary unit (symbol)*	*Non-SI alternative unit (symbol)*
1.	***Direction/Space/Time***		
1.1	altitude	m	ft
1.2	area	m^2	
1.3	distance (long)[a)]	km	NM
1.4	distance (short)	m	
1.5	elevation	m	ft
1.6	endurance	h and min	
1.7	height	m	ft
1.8	latitude	° ' "	
1.9	length	m	ft/in
1.10	longitude	° ' "	
1.11	plane angle (when required, decimal subdivisions of the degree shall be used)	°	
1.12	runway length	m	
1.13	runway visual range	m	
1.14	tank capacities (aircraft)[b)]	L	
1.15	time	s min h d week month year	
1.16	visibility[c)]	km	
1.17	volume	m^3	
1.18	wind direction (wind directions other than for a landing and take-off shall be expressed in degrees true; for landing and take-off wind directions shall be expressed in degrees magnetic)	°	
2.	***Mass-related***		
2.1	air density	kg/m^3	
2.2	area density	kg/m^2	
2.3	cargo capacity	kg	
2.4	cargo density	kg/m^3	
2.5	density (mass density)	kg/m^3	
2.6	fuel capacity (gravimetric)	kg	
2.7	gas density	kg/m^3	
2.8	gross mass or payload	kg t	pounds
2.9	hoisting provisions	kg	
2.10	linear density	kg/m	
2.11	liquid density	kg/m^3	
2.12	mass	kg	
2.13	moment of inertia	$kg \cdot m^2$	
2.14	moment of momentum	$kg \cdot m^2/s$	
2.15	momentum	$kg \cdot m/s$	

Ref. No.	*Quantity*	*Primary unit (symbol)*	*Non-SI alternative unit (symbol)*
3.	***Force-related***		
3.1	air pressure (general)	kPa	
3.2	altimeter setting	hPa	
3.3	atmospheric pressure	hPa	
3.4	bending moment	kN · m	
3.5	force	N	
3.6	fuel supply pressure	kPa	
3.7	hydraulic pressure	kPa	Psi
3.8	modulus of elasticity	MPa	
3.9	pressure	kPa	
3.10	stress	MPa	
3.11	surface tension	mN/m	
3.12	thrust	kN	
3.13	torque	N · m	
3.14	vacuum	Pa	
4.	***Mechanics***		
4.1	airspeed[d)]	km/h	kt
4.2	angular acceleration	rad/s^2	
4.3	angular velocity	rad/s	
4.4	energy or work	J	
4.5	equivalent shaft power	kW	
4.6	frequency	Hz	
4.7	ground speed	km/h	kt
4.8	impact	J/m^2	
4.9	kinetic energy absorbed by brakes	MJ	
4.10	linear acceleration	m/s^2	
4.11	power	kW	
4.12	rate of trim	°/s	
4.13	shaft power	kW	
4.14	velocity	m/s	
4.15	vertical speed	m/s	ft/min
4.16	wind speed	km/h	kt
5.	***Flow***		
5.1	engine airflow	kg/s	
5.2	engine waterflow	kg/h	
5.3	fuel consumption (specific)		
	piston engines	kg/(kW · h)	pounds/hr
	turbo-shaft engines	kg/(kW · h)	
	jet engines	kg/(kN · h)	
5.4	fuel flow	kg/h	pounds/hr
5.5	fuel tank filling rate (gravimetric)	kg/min	
5.6	gas flow	kg/s	
5.7	liquid flow (gravimetric)	g/s	
5.8	liquid flow (volumetric)	L/s	
5.9	mass flow	kg/s	
5.10	oil consumption		
	gas turbine	kg/h	quarts/hr
	piston engines (specific)	g/(kW · h)	

Ref. No.	*Quantity*	*Primary unit (symbol)*	*Non-SI alternative unit (symbol)*
5.11	oil flow	g/s	
5.12	pump capacity	L/min	
5.13	ventilation airflow	m^3/min	
5.14	viscosity (dynamic)	$Pa \cdot s$	
5.15	viscosity (kinematic)	m^2/s	
6.	***Thermodynamics***		
6.1	coefficient of heat transfer	$W/(m^2 \cdot K)$	
6.2	heat flow per unit area	J/m^2	
6.3	heat flow rate	W	
6.4	humidity (absolute)	g/kg	
6.5	coefficient of linear expansion	$°C^{-1}$	
6.6	quantity of heat	J	
6.7	temperature	°C	
7.	***Electricity and magnetism***		
7.1	capacitance	F	
7.2	conductance	S	
7.3	conductivity	S/m	
7.4	current density	A/m^2	
7.5	electric current	A	
7.6	electric field strength	C/m^2	
7.7	electric potential	V	
7.8	electromotive force	V	
7.9	magnetic field strength	A/m	
7.10	magnetic flux	Wb	
7.11	magnetic flux density	T	
7.12	power	W	
7.13	quantity of electricity	C	
7.14	resistance	Ω	
8.	***Light and related electromagnetic radiations***		
8.1	illuminance	lx	
8.2	luminance	cd/m^2	
8.3	luminous exitance	lm/m^2	
8.4	luminous flux	lm	
8.5	luminous intensity	cd	
8.6	quantity of light	$lm \cdot s$	
8.7	radiant energy	J	
8.8	wavelength	m	
9.	***Acoustics***		
9.1	frequency	Hz	
9.2	mass density	kg/m^3	
9.3	noise level	dB[e)]	
9.4	period, periodic time	s	
9.5	sound intensity	W/m^2	
9.6	sound power	W	
9.7	sound pressure	Pa	
9.8	sound level	dB[e)]	

Ref. No.	*Quantity*	*Primary unit (symbol)*	*Non-SI alternative unit (symbol)*
9.9	static pressure (instantaneous)	Pa	Psi
9.10	velocity of sound	m/s	
9.11	volume velocity (instantaneous)	m^3/s	
9.12	wavelength	m	
10.	***Nuclear physics and ionizing radiation***		
10.1	absorbed dose	Gy	
10.2	absorbed dose rate	Gy/s	
10.3	activity of radionuclides	Bq	
10.4	dose equivalent	Sv	
10.5	radiation exposure	C/kg	
10.6	exposure rate	C/kg · s	

a) As used in navigation, generally in excess of 4 000 m.
b) Such as aircraft fuel, hydraulic fluids, water, oil and high pressure oxygen vessels.
c) Visibility of less than 5 km may be given in m.
d) Airspeed is sometimes reported in flight operations in terms of the ratio MACH number.
e) The decibel (dB) is a ratio which may be used as a unit for expressing sound pressure level and sound power level. When used, the reference level must be specified.

CHAPTER 4 – TERMINATION OF USE OF NON-SI ALTERNATIVE UNITS

4.1 The use in international civil aviation operations of the alternative non-SI units listed in Table 3-3 shall be terminated on the dates listed in Table 4- 1.

Table 4-1 – Termination dates for non-SI alternative units

Non-SI alternative unit	*Termination date*
Knot **Nautical mile**	**not established[a)]**
Foot	**not established[b)]**

a) No termination date has yet been established for use of nautical mile and knot.
b) No termination date has yet been established for use of the foot.

CIVIL AVIATION DEPARTMENT
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ATTACHMENT A – DEVELOPMENT OF THE INTERNATIONAL SYSTEM OF UNITS (SI)

1. Historical background

1.1 The name SI is derived from "Systeme International d' Unites”. The system has evolved from units of length and mass (metre and kilogram) which were created by members of the Paris Academy of Sciences and adopted by the French National Assembly in 1795 as a practical measure to benefit industry and commerce. The original system became known as the metric system. Physicists realized the advantages of the system and it was soon adopted in scientific and technical circles.

1.2 International standardization began with an 1870 meeting of 15 States in Paris that led to the International Metric Convention in 1875 and the establishment of a permanent International Bureau of Weights and Measures. A General Conference on Weights and Measures (CGPM) was also constituted to handle all international matters concerning the metric system. In 1889 the first meeting of the CGPM legalized the old prototype of the metre and the kilogram as the international standard for unit of length and unit of mass respectively. Other units were agreed in subsequent meetings and by its 10th Meeting in 1954, the CGPM had adopted a rationalized and coherent system of units based on the metre-kilogram-second-ampere (MKSA) system which had been developed earlier, plus the addition of the kelvin as the unit of temperature and the candela as the unit of luminous intensity. The 11th CGPM, held in 1960 and in which 36 States participated, adopted the name International System of Units (SI) and laid down rules for the prefixes, the derived and supplementary units and other matters, thus establishing comprehensive specifications for international units of measurement. The 12th CGPM in 1964 made some refinements in the system, and the 13th CGPM in 1967 redefined the second, renamed the unit of temperature as the kelvin (K) and revised the definition of the candela. The 14th CGPM in 1971 added a seventh base unit, the mole (mol) and approved the pascal (Pa) as a special name for the S1 unit of pressure or stress, the newton (N) per square metre (m2) and the siemens (S) as a special name for the unit of electrical conductance. In 1975 the CGPM adopted the becquerel (Bq) as the unit of the activity of radionuclides and the gray (Gy) as the unit for absorbed dose.

2. International Bureau of Weights and Measures

2.1 The Bureau International des Poids et Mesures (BIPM) was set up by the Metre Convention signed in Paris on 20 May 1875 by 17 States during the final session of the Diplomatic Conference of the Metre. This Convention was amended in 1921. BIPM has its headquarters near Paris and its upkeep is financed by the Member States of the Metre Convention. The task of BIPM is to ensure world-wide unification of physical measurements; it is responsible for:

- establishing the fundamental standards and scales for measurement of the principal physical quantities and maintaining the international prototypes;

- carrying out comparisons of national and international standards;

- ensuring the co-ordination of corresponding measuring techniques;

- carrying out and co-ordinating the determinations relating to the fundamental physical constants.

2.2 BIPM operates under the exclusive supervision of the International Committee of Weights and Measures (CIPM), which itself comes under the authority of the General Conference of Weights and Measures (CGPM). The International Committee consists of 18 members each belonging to a different State; it meets at least once every two years. The officers of this Committee issue an Annual Report on the administrative and financial position of BIPM to the Governments of the Member States of the Metre Convention.

2.3 The activities of BIPM, which in the beginning were limited to the measurements of length and mass and to metrological studies in relation to these quantities, have been extended to standards of measurement for electricity (1927), photometry (1937) and ionizing radiations (1960). To this end the original laboratories, built in 1876-78, were enlarged in 1929 and two new buildings were constructed in 196364 for the ionizing radiation laboratories. Some 30 physicists or technicians work in the laboratories of BIPM. They do metrological research, and also undertake measurement and certification of material standards of the above-mentioned quantities.

2.4 In view of the extension of the work entrusted to BIPM, CIPM has set up since 1927, under the name of Consultative Committees, bodies designed to provide it with information on matters which it refers to them for study and advice. These Consultative Committees, which may form temporary or permanent working groups to study special subjects, are responsible for co-ordinating the international work carried out in their respective fields and proposing recommendations concerning the amendment to be made to the definitions and values of units. In order to ensure worldwide uniformity in units of measurement, the International Committee accordingly acts directly or submits proposals for sanction by the General Conference.

2.5 The Consultative Committees have common regulations ***(Procgs-Verbaux CIPM,* 1963, *31,* 97).** Each Consultative Committee, the chairman of which is normally a member of CIPM, is composed of a delegate from each of the large metrology laboratories and specialized institutes, a list of which is drawn up by CIPM, as well as individual members also appointed by CIPM and one representative of BIPM. These Committees hold their meetings at irregular intervals; at present there are seven of them in existence as follows:

I. The Consultative Committee for Electricity (CCE), set up in **1937.**

2. The Consultative Committee for Photometry and Radiometry (CCPR), which is the new name given in **1971** to the Consultative Committee for Photometry set up in **1933** (between **1930** and **1933** the preceding committee (CCE) dealt with matters concerning photometry).

3. The Consultative Committee for Thermometry (CCT), set up in **1937.**

4. The Consultative Committee for the Definition of the Metre (CCDM), set up in **1952.**

5. The Consultative Committee for the Definition of the Second (CCDS), set up in **1956.**

6. The Consultative Committee for the Standards of Measurement of Ionizing Radiations (CCEMRI), set up in **1958.** Since **1969** this Consultative Committee has consisted of four sections: Section I (measurement of X- and Y-rays); Section 11 (measurement of radionuclides); Section 111 (neutron measurements); Section IV (a-energy standards).

7. The Consultative Committee for Units (CCU), set up in **1964.**

The proceedings of the General Conference, the International Committee, the Consultative Committees and the Inter-national Bureau are published under the auspices of the latter in the following series:

- Comptes rendus des seances de la Conference Generule des Poids et Mesures;
- Procis-Verbaux des sPances du Cornit& International des Poids et Mesures;
- Sessions des Comites Consultatifs;
- Recueil de Travaux du Bureau International des Poids et Mesures (this compilation brings together articles published in scientific and technical journals and books, as well as certain work published in the form of duplicated reports).

2.6 From time to time BIPM publishes a report on the development of the metric system throughout the world, entitled ***Les recents progres du Systeme Metrique.*** The collection of the ***Travaux et Memoires du Bureau International des Poids et Mesures*** **(22** volumes published between **1881** and **1966)** ceased in **1966** by a decision of the CIPM. Since **1965** the international journal ***Metrologia,*** edited under the auspices of CIPM, has published articles on the more important work on scientific metrology carried out throughout the world, on the improvement in measuring methods and standards, of units, etc, as well as reports concerning the activities, decisions and recommendations of the various bodies created under the Metre Convention.

3. International Organization for Standardization

The International Organization for Standardization (ISO) is a world-wide federation of national standards institutes which, although not a part of the BIPM, provides recommendations for the use of SI and certain other units. IS0 Document **1000** and the IS0 Recommendation **R31** series of documents provide extensive detail on the application of the SI units. 1CAO maintains liaison with IS0 regarding the standardized application of SI units in aviation.

ATTACHMENT B – GUIDANCE ON THE APPLICATION OF THE SI

1. Introduction

1.1 The International system of units is a complete coherent system which includes three classes of units:

a) base units;

b) supplementary units; and

C) derived units.

1.2 The SI is based on seven units which are dimensionally independent and are listed in Table B-I.

Table B-1. SI base units

Quantity	*Unit*	*Symbol*
amount of a substance	mole	mol
electric current	ampere	A
length	metre	m
luminous intensity	candela	cd
mass	kilogram	kg
thermodynamic temperature	kelvin	K
time	second	s

1.3 The supplementary units of the SI are listed in Table B-2 and may be regarded either as base units or as derived Units.

Table B-2. SI supplementary units

Quantity	*Unit*	*Symbol*
plane angle	radian	rad
solid angle	steradian	sr

1.4 Derived units of the SI are formed by combining base units, supplementary units and other derived units according to the algebraic relations linking the corresponding quantities. The symbols for derived units are obtained by means of the mathematical signs for multiplication, division and the use of exponents. Those derived SI units which have special names and symbols are listed in Table B-3.

Table B-3. SI derived units with special names

Quantity	*Unit*	*Symbol*	*Derivation*
absorbed dose (radiation)	gray	Gy	J/kg
activity of radionuclides	becquerel	Bq	1/s
capacitance	farad	F	C/V
conductance	siemens	S	A/V
dose equivalent (radiation)	sievert	Sv	J/kg
electric potential, potential difference, electromotive force	volt	V	W/A
electric resistance	ohm	Ω	V/A
energy, work, quantity of heat	joule	J	N·m
force	newton	N	$kg \cdot m/s^2$
frequency (of a periodic phenomenon)	hertz	Hz	1/s
illuminance	lux	lx	lm/m^2
inductance	henry	H	Wb/A
luminous flux	lumen	lm	cd·sr
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m^2
power, radiant flux	watt	W	J/s
pressure, stress	pascal	Pa	N/m^2
quantity of electricity, electric charge	coulomb	C	A·s

1.5 The SI is a rationalized selection of units from the metric system which individually are not new. The great advantage of SI is that there is only one unit for each physical quantity - the metre for length, kilogram (instead of gram) for mass, second for time, etc. From these elemental or base units, units for all other mechanical quantities are derived. These derived units are defined by simple relationships such as velocity equals rate of change of distance, acceleration equals rate of change of velocity, force is the product of mass and acceleration, work or energy is the product of force and distance, power is work done per unit time, etc. Some of these units have only generic names such as metre per second for velocity; others have special names such as newton (N) for force, joule (J) for work or energy, watt (W) for power. The SI units for force, energy and power are the same regardless of whether the process is mechanical, electrical, chemical or nuclear. **A** force of 1 newton applied for a distance of **1** metre can produce 1 joule of heat, which is identical with what **1** watt of electric power can produce in 1 second.

1.6 Corresponding to the advantages of SI, which result from the use of a unique unit for each physical quantity, are the advantages which result from the use of a unique and welldefined set of symbols and abbreviations. Such symbols and abbreviations eliminate the confusion that can arise from current practices in different disciplines such as the use of "**b**" for both the bar (a unit of pressure) and barn (a unit of area).

1.7 Another advantage of SI is its retention of the decimal relation between multiples and sub-multiples of the base units for each physical quantity. Prefixes are established for designating multiple and sub-multiple units from "exa" (lot8) down to "atto" for convenience in writing and speaking.

I .8 Another major advantage of SI is its coherence. Units might be chosen arbitrarily, but making an independent choice of a unit for each category of mutually comparable quantities would lead in general to the appearance of several additional numerical factors in the equations between the numerical values. It is possible, however, and in practice more convenient, to choose a system of units in such a way that the equations between numerical values, including the numerical factors, have exactly the same form as the corresponding equations between the quantities. A unit system defined in this way is called coherent with respect to the system of quantities and equations in question. Equations between units of a coherent unit system contain as numerical factors only the number 1. In a coherent system the product or quotient of any two unit quantities in the unit of the resulting quality. For example, in any coherent system unit area results when unit length is multiplied by unit length, unit velocity when unit length is divided by unit time, and unit force when unit mass is multiplied by unit acceleration.

2. Mass Force and Weight

2.1 The principal departure of SI from the gravimetric system of metric engineering units is the use of explicitly distinct units from mass and force. In SI, the name kilogram is restricted to the unit of mass, and the kilogram-force (from which the suffix force was in practice often erroneously dropped) is not to be used. In its place the SI unit of force, the newton is used. Likewise, the newton rather than the kilogram-force is used to form derived units which include force, for example, pressure or stress (N/m2 = Pa), energy (N . m = J), and power (N . m/s = W).

2.2 Considerable confusion exists in the use of the term weight as a quantity to mean either force or mass. In common use, the term weight nearly always means mass; thus, when one speaks of a person's weight, the quantity referred to is mass. in science and technology, the term weight of a body has usually meant the force that, if applied to the body, would give it **an** acceleration equal to the local acceleration of free fall. The adjective "local" in the phrase "local acceleration of free fall" has usually meant a location on the surface of the earth; in this context the "local acceleration of free fall" has the symbol g (sometimes referred to as "acceleration of gravity") with observed values of g differing by over 0.5 per cent at various points on the earth's surface and decreasing as distance from the earth is increased. Thus, because weight is a force = mass x acceleration due to gravity, a person's weight is conditional on his location, but mass is not. **A** person with a mass of 70 kg might experience a force (weight) on earth of 686 newtons (- **155** lbf) and a force (weight) of only 113 newtons (- **22** lbf) on the moon. Because of the dual use of the term weight as a quantity, the term weight should be avoided in technical practice except under circumstances in which its meaning is completely clear. When the term is used, it is important to know whether mass or force is intended and to use S1 units properly by using kilograms for mass or newtons for force.

2.3 Gravjty is involved in determining mass with a balance or scale. When a standard mass is used to balance the measured mass, the direct effect of gravity on the two masses is cancelled, but the indirect effect through the buoyancy of air or other fluid is generally not cancelled. In using a spring scale, mass is measured indirectly, since the instrument responds to the force of gravity. Such scales may be calibrated in mass units if the variation in acceleration of gravity and buoyancy corrections are not significant in their use.

3. Energy and torque

3.1 The vector product of force and moment arm is widely designated by the unit newton metre. This unit for bending moment or torque results in confusion with unit for energy, which is also newton metre. **If** torque is expressed as Newton metre per radian, the relationship to energy is classified, since the product of torque and angular rotation is energy

(N . m/rad) . rad = N - **m**

3.2 If vectors were shown, the distinction between energy and torque would be obvious, since the orientation of force and is different in two cases. It is important to recognize this difference in using torque and energy and joule should never be used for torque.

4. *SI* ***prefixes***

4.1 Selection of prefixes

4.1.1 In general the SI prefixes should be used to indicate orders of magnitude, thus eliminating non-significant digits and leading zeros in decimal fractions, and providing a convenient alternative to the powers-of-ten notation preferred in computation. For

example:

12 300 mm becomes 12.3 m
12.3 x 10^3 m becomes 12.3 km
0.00123 µA becomes 1.23 nA

4.1.2 When expressing a quantity by a numerical value and a unit, prefixes should preferably be chosen so that the numerical value lies between 0.1 and 1 000. To minimize variety, it is recommended that prefixes representing powers of 1 000 be used. However, in the following cases, deviation from the above may be indicated:

a) in expressing area and volume, the prefixes hecto, deca, deci and centi may be required: for example, square hectometre, cubic centimetre;

b) in tables of values of the same quantity, or in a discussion of such values within a given context, it is generally preferable to use the same unit multiple throughout; and

c) for certain quantities in particular applications, one particular multiple is customarily used. For example, the hectopascal is used for altimeter settings and the millimetre is used for linear dimensions in mechanical engineering drawings even when the values lie outside the range 0.1 to 1 000.

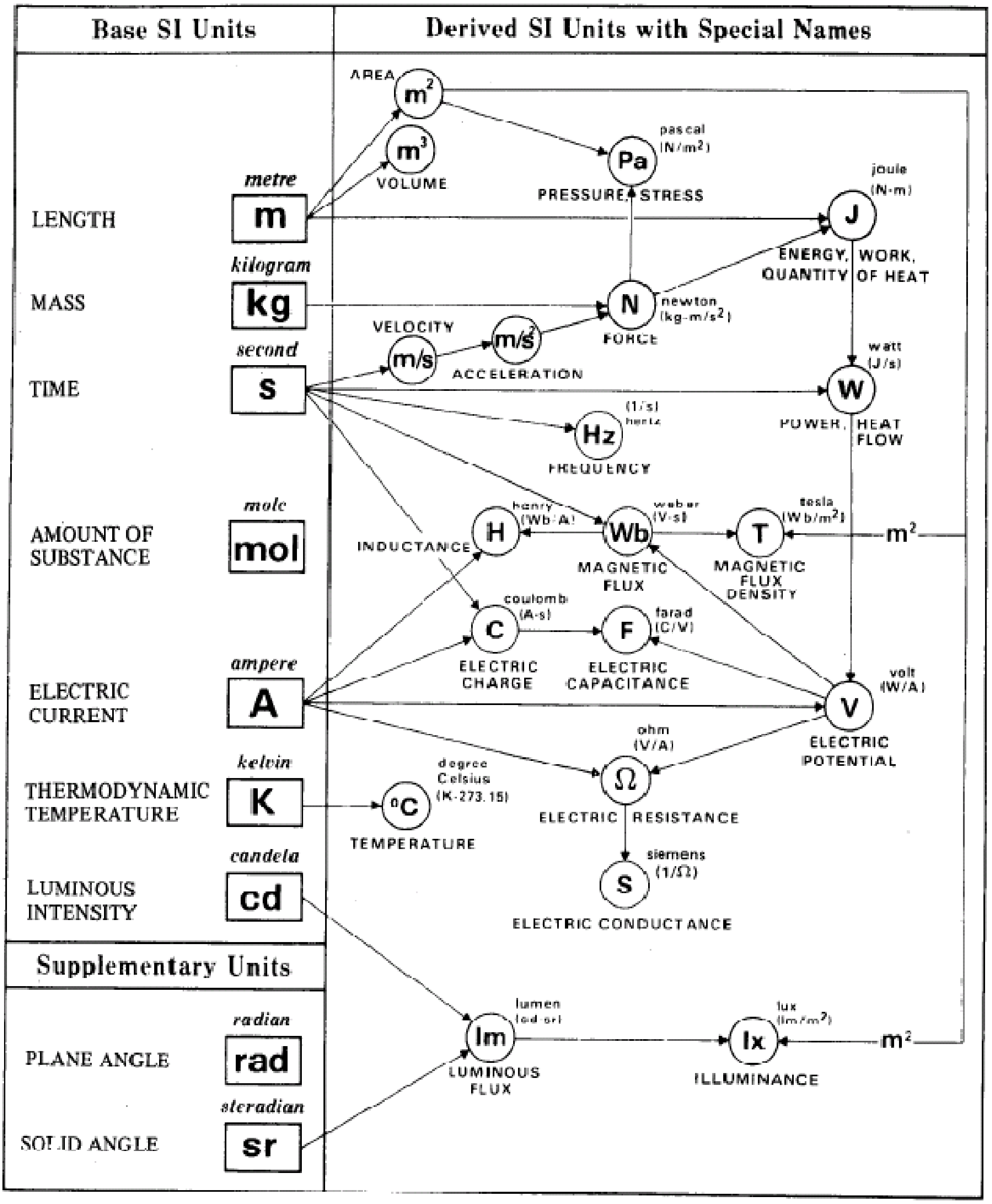
Base SI Units
Derived SI Units with Special Names
LENGTH
metre
m
MASS
kilogram
kg
TIME
second
s
AMOUNT OF SUBSTANCE
mole
mol
ELECTRIC CURRENT
ampere
A
THERMODYNAMIC TEMPERATURE
kelvin
K
LUMINOUS INTENSITY
candela
cd
Supplementary Units
PLANE ANGLE
radian
rad
SOLID ANGLE
steradian
sr
AREA
m2
m3
VOLUME
Pa
pascal
(N/m2)
PRESSURE, STRESS
J
joule
(N·m)
ENERGY, WORK, QUANTITY OF HEAT
N
newton
(kg·m/s2)
FORCE
VELOCITY
m/s
m/s2
ACCELERATION
W
watt
(J/s)
POWER, HEAT FLOW
Hz
(1/s)
hertz
FREQUENCY
H
henry
(Wb/A)
INDUCTANCE
Wb
weber
(V·s)
MAGNETIC FLUX
T
tesla
(Wb/m2)
MAGNETIC FLUX DENSITY
m2
C
coulomb
(A·s)
ELECTRIC CHARGE
F
farad
(C/V)
ELECTRIC CAPACITANCE
V
volt
(W/A)
ELECTRIC POTENTIAL
Ω
ohm
(V/A)
ELECTRIC RESISTANCE
°C
degree Celsius
(K-273.15)
TEMPERATURE
S
siemens
(1/Ω)
ELECTRIC CONDUCTANCE
lm
lumen
(cd·sr)
LUMINOUS FLUX
lx
lux
(lm/m2)
ILLUMINANCE
m2

Figure B-1

4.2 Prefixes in compound units

It is recommended that only one prefix be used in forming a multiple of a compound unit. Normally the prefix should be attached to a unit in the numerator. One exception to this occurs when the kilogram is one of the units. For example: V/m, ***not*** mV/mm; MJ/kg, ***not*** kJ/g

4.3 Compound prefixes

Compound prefixes, formed by the juxtaposition of two or more SI prefixes, are not to be used. For example: 1 nm ***not*** I mpm; 1 pF ***not*** 1wF

values are required outside the range covered by the prefixes, they should be expressed using powers of ten applied to the base unit.

4.4 Powers of units

An exponent attached to a symbol containing a prefix indicates that the multiple or sub-multiple of the unit (the unit with its prefix) is raised to the power expressed by the exponent. For example:

$1\ cm^3 = (IO^{-2} m)^3 = 10^{-6}\ m^3$
$1 ns^{-1} = (10^{-9}\ s)^{-1} = 10^9\ s^{-1}$
$1\ mm^2/s = (10^{-3}\ m)^2/s = 10^{-6}\ m^2/s$

5. Style and usage

5.1 Rules for writing unit symbols

5.1.1 Unit symbols should be printed in Roman (upright) type regardless of the type style used in the surrounding text.

0.00123 µA becomes 1.23 nA

5.1.2 Unit symbols are unaltered in the plural.

5.1.3 Unit symbols are not followed by a period except when used at the end of a sentence.

5.1.4 Letter unit symbols are written in lower case (cd) unless the unit name has been derived from a proper name, in which case the first letter of the symbol is capitalized (W, Pa). Prefix and unit symbols retain their prescribed form regardless of the surrounding typography.

5.1.5 In the complete expression for a quantity, a space should be left between the numerical value and the unit symbol. For example, write 35 mm not 35mm, and 2.37lm, not 2.371m. When the quantity is used in an adjectival sense, a hyphen is often used, for example, 35-mm film.

Exception: No space is left between the numerical value and the symbols for degree, minute and second of plane angle, and degree Celsius.

5.1.6 No space is used between. the prefix and unit symbols.

5.1.7 Symbols. not abbreviations. should be used for units. For example, use "A", not "amp", for ampere.

5.2 Rules for writing unit names

5.2.1 Spelled-out unit names are treated as common nouns in English. Thus, the first letter of a unit name is not capitalized except at the beginning of a sentence or in capitalized material such as a title, even though the unit name may be derived from a proper name and therefore be represented as a symbol by a capital letter (see 5.1.4).

For example, normally write "newton" not "Newton" even though the symbol is N.

A compound unit is a derived unit expressed in terms of two or more units, that is. not expressed with a single special name.

5.2.2 Plurals are used when required by the rules of grammar and are normally formed regularly, for example, henries for the plural of henry. The following irregular plurals are recommended:

Singular	***Plural***
Lux	lux
Hertz	hertz
Siemens	Siemens

5.2.3 No space or hyphen is used between the prefix and the unit name.

5.3 Units formed by multiplication and division

5.3.1 *With unit names:*

Product, use a space (preferred) or hyphen:

newton metre ***or*** newton-metre in the case of the watt hour the space may be omitted, thus:

watthour.

Quotient, use the word per and not a solidus:

metre per second ***not*** metre/second.

Powers, use the modifier squared or cubed placed after the unit name:

metre per second squared

In the case of area or volume, a modifier may be placed before the unit name:

quare millimetre, cubic metre.

This exception also applies to derived units using area or volume:

watt per square metre.

Note.- To avoid ambiguity in complicated expressions, symbols are preferred to words.

5.3.2 ***With unit symbols:***

Product may be indicated in either of the following ways:

Nm ***or*** N · m for newton metre.

Note – When using for a prefix a symbol which coincides with the symbol for the unit, special care should be taken to avoid confusion. The unit newton metre for torque should be written, for example, Nm *or* N · m *to avoid confusion with* mN, *the millinewton.*

An exception to this practice is made for computer printouts, automatic typewriter work, etc., where the dot half high is not possible, and a dot on the line may be used.

Quotient, use one of the following forms:

m/s ***or*** $m \cdot s^{-1}$ ***or*** $\frac{m}{S}$

In no case should more than one solidus be used in the same expression unless parentheses are inserted to avoid ambiguity. For example, write:

J/(mol · K) ***or*** $J \cdot mol^{-1} \cdot K^{-1}$ ***or*** (J/mol)/K but ***not*** J/mol/K.

5.3.3 Symbols and unit names should not be mixed in the same expression. Write:

joules per kilogram ***or*** J/kg ***or*** $J \cdot kg^{-1}$ but ***not*** joules/kilogram ***or*** joules/kg ***or*** joules $\cdot\ kg^{-1}$.

5.4 Numbers

5.4.1 The preferred decimal marker is a point on the line (period); however, the comma is also acceptable. When writing numbers less than one, a zero should be written before the decimal marker.

5.4.2 The comma is not to be used to separate digits. Instead, digits should be separated into groups of three, counting from the decimal point towards the left and the right, and using a small space to separate the groups.

For example:

The space between groups should be approximately the width of the letter '5" and the width of the space should be constant even if, as is often the case in printing, variable-width spacing is used between the words.

5.4.3 The sign for multiplication of numbers is a cross **(x)** or a dot half high. However, if the dot half high is used as the multiplication sign, a point on the line must not be used as a decimal marker in the same expression.

5.4.4 Attachment of letters to a unit symbol as a means of giving information about the nature of the quantity under consideration is incorrect. Thus MWe for "megawatts electrical (power)", Vac for "volts ac" and kJt for "kilojoules thermal (energy)" are not acceptable. For this reason, no attempt should be made to construct SI equivalents of the abbreviations "psia" and "psig", so often used to distinguish between absolute and gauge pressure. If the context leaves any doubt as to which is meant, the word pressure must be qualified appropriately. For example: ". . . at a gauge pressure of **13** kPa". ***or*** " . . . at an absolute pressure of **13** kPa".

ATTACHMENT C. CONVERSION FACTORS

1. General

1.1 The list of conversion factors which is contained in this Attachment is provided to express the definitions of miscellaneous units of measure as numerical multiples of SI units.

1.2 The conversion factors are presented for ready adaptation to computer read-out and electronic data transmission. The factors are written as a number greater than 1 and less than 10 with six or less decimal places. This number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value.

For example: 3.523 907 E is 3.523 907 x 10^{-2} or 0.035 239 07

Similarly, 3.386 389 E = 03 is 3.386 389 x 10^{3} or 3 386.389

1.3 An asterisk (*) after the sixth decimal place indicates that the conversion factor is exact and that all subsequent digits are zero. Where less than six decimal places are shown, more precision is not warranted.

1.4 Further examples of use of the tables:

To convert from	***to***	***Multiply by***
pound-force per square foot	Pa	4.788 026 E + 01
inch	**m**	2.540 000*E-02

thus:

1 Ibf/ft2 = 47.880 26 Pa
1 inch = 0.025 4 **m** (exactly)

2. Factors **not** listed

2.1 Conversion factors for compound units which are not listed herein can easily be developed from numbers given in the list by the substitution of converted units, as follows.

Example: To find conversion factor of Ib.ft/s to kg.rn/s:

first convert

1 lb to 0.453 592 4 kg

1 ft to 0.304 8 m

then substitute:

(0.453 592 4 kg) x (0.304 8 m)/s
= 0.138 255 kg.m/s

Thus the factor is 1.382 55 E-01.

TABLE C-1

CONVERSION FACTORS TO SI UNITS (SYMBOLS OF SI UNITS GIVEN IN PARANTHESES)

To convert from	*to*	*Multiply by*
abampere	ampere (A)	1.000 000*E+01
abcoulomb	coulomb (C)	1.000 000*E+01
abfarad	farad (F)	1.000 000*E+09
abhenry	henry (H)	1.000 000*E−09
abmho	siemens (S)	1.000 000*E+09
abohm	ohm (Ω)	1.000 000*E−09
abvolt	volt (V)	1.000 000*E−08
acre (U.S. survey)	square metre (m^2)	4.046 873 E+03
ampere hour	coulomb (C)	3.600 000*E+03
are	square metre (m^2)	1.000 000*E+02
atmosphere (standard)	pascal (Pa)	1.013 250*E+05
atmosphere (technical = 1 kgf/cm^2)	pascal (Pa)	9.806 650*E+04
bar	pascal (Pa)	1.000 000*E+05
barrel (for petroleum, 42 U.S. liquid gal)	cubic metre (m^3)	1.589 873*E−01

Note : An astric (*) after the sixth decimal place indicates that the conversion factor is exact and that all subsequent digits are zero. Where less than six decimal places are shown, more precision is not warranted

Table C-1 *(cont.)*

To convert from	*to*	*Multiply by*
British thermal unit (International Table)	joule (J)	1.055 056 E+03
British thermal unit (mean)	joule (J)	1.055 87 E+03
British thermal unit (thermochemical)	joule (J)	1.054 350 E+03
British thermal unit (39°F)	joule (J)	1.059 67 E+03
British thermal unit (59°F)	joule (J)	1.054 80 E+03
British thermal unit (60°F)	joule (J)	1.054 68 E+03
Btu (International Table)·ft/h·ft²·°F (k, thermal conductivity)	watt per metre kelvin (W/m·K)	1.730 735 E+00
Btu (thermochemical)·ft/h·ft²·°F (k, thermal conductivity)	watt per metre kelvin (W/m·K)	1.729 577 E+00
Btu (International Table)·in/h·ft²·°F (k, thermal conductivity)	watt per metre kelvin (W/m·K)	1.442 279 E−01
Btu (thermochemical)·in/h·ft²·°F (k, thermal conductivity)	watt per metre kelvin (W/m·K)	1.441 314 E−01
Btu (International Table)·in/s·ft²·°F (k, thermal conductivity)	watt per metre kelvin (W/m·K)	5.192 204 E+02
Btu (thermochemical)·in/s·ft²·°F (k, thermal conductivity)	watt per metre kelvin (W/m·K)	5.188 732 E+02
Btu (International Table)/h	watt (W)	2.930 711 E−01
Btu (thermochemical)/h	watt (W)	2.928 751 E−01
Btu (thermochemical)/min	watt (W)	1.757 250 E+01
Btu (thermochemical)/s	watt (W)	1.054 350 E+03
Btu (International Table)/ft²	joule per square metre (J/m²)	1.135 653 E+04
Btu (thermochemical)/ft²	joule per square metre (J/m²)	1.134 893 E+04
Btu (thermochemical)/ft²·h	watt per square metre (W/m²)	3.152 481 E+00
Btu (thermochemical)/ft²·min	watt per square metre (W/m²)	1.891 489 E+02
Btu (thermochemical)/ft²·s	watt per square metre (W/m²)	1.134 893 E+04
Btu (thermochemical)/in²·s	watt per square metre (W/m²)	1.634 246 E+06
Btu (International Table)/h·ft²·°F (C, thermal conductance)	watt per square metre kelvin (W/m²·K)	5.678 263 E+00
Btu (thermochemical)/h·ft²·°F (C, thermal conductance)	watt per square metre kelvin (W/m²·K)	5.674 466 E+00
Btu (International Table)/s·ft²·°F	watt per square metre kelvin (W/m²·K)	2.044 175 E+04
Btu (thermochemical)/s·ft²·°F	watt per square metre kelvin (W/m²·K)	2.042 808 E+04
Btu (International Table)/lb	joule per kilogram (J/kg)	2.326 000*E+03
Btu (thermochemical)/lb	joule per kilogram (J/kg)	2.324 444 E+03
Btu (International Table)/lb·°F (c, heat capacity)	joule per kilogram kelvin (J/kg·K)	4.186 800*E+03
Btu (thermochemical)/lb·°F (c, heat capacity)	joule per kilogram kelvin (J/kg·K)	4.184 000 E+03
calibre (inch)	metre (m)	2.540 000*E−02
calorie (International Table)	joule (J)	4.186 800*E+00
calorie (mean)	joule (J)	4.190 02 E+00
calorie (thermochemical)	joule (J)	4.184 000*E+00
calorie (15°C)	joule (J)	4.185 80 E+00
calorie (20°C)	joule (J)	4.181 90 E+00
calorie (kilogram, International Table)	joule (J)	4.186 800*E+03
calorie (kilogram, mean)	joule (J)	4.190 02 E+03
calorie (kilogram, thermochemical)	joule (J)	4.184 000*E+03
cal (thermochemical)/cm²	joule per square metre (J/m²)	4.184 000*E+04

Table C-1 *(cont.)*

To convert from	*to*	*Multiply by*
cal (International Table)/g	joule per kilogram (J/kg)	4.186 800*E+03
cal (thermochemical)/g	joule per kilogram (J/kg)	4.184 000*E+03
cal (International Table)/g·°C	joule per kilogram kelvin (J/kg·K)	4.186 800*E+03
cal (thermochemical)/g·°C	joule per kilogram kelvin (J/kg·K)	4.184 000*E+03
cal (thermochemical)/min	watt (W)	6.973 333 E−02
cal (thermochemical)/s	watt (W)	4.184 000*E+00
cal (thermochemical)/cm²·min	watt per square metre (W/m²)	6.973 333 E+02
cal (thermochemical)/cm²·s	watt per square metre (W/m²)	4.184 000*E+04
cal (thermochemical)/cm·s·°C	watt per metre kelvin (W/m·K)	4.184 000*E+02
centimetre of mercury (0°C)	pascal (Pa)	1.333 22 E+03
centimetre of water (4°C)	pascal (Pa)	9.806 38 E+01
centipoise	pascal second (Pa·s)	1.000 000*E−03
centistokes	metre squared per second (m²/s)	1.000 000*E−06
circular mil	square metre (m²)	5.067 075 E−10
clo	kelvin metre squared per watt (K·m²/W)	2.003 712 E−01
cup	cubic metre (m³)	2.365 882 E−04
curie	becquerel (Bq)	3.700 000*E+10
day (mean solar)	second (s)	8.640 000 E+04
day (sidereal)	second (s)	8.616 409 E+04
degree (angle)	radian (rad)	1.745 329 E−02
°F·h·ft²/Btu (International Table) (R, thermal resistance)	kelvin metre squared per watt (K·m²/W)	1.761 102 E−01
°F·h·ft²/Btu (thermochemical) (R, thermal resistance)	kelvin metre squared per watt (K·m²/W)	1.762 280 E−01
dyne	newton (N)	1.000 000*E−05
dyne·cm	newton metre (N·m)	1.000 000*E−07
dyne/cm²	pascal (Pa)	1.000 000*E−01
electronvolt	joule (J)	1.602 19 E−19
EMU of capacitance	farad (F)	1.000 000*E+09
EMU of current	ampere (A)	1.000 000*E+01
EMU of electric potential	volt (V)	1.000 000*E−08
EMU of inductance	henry (H)	1.000 000*E−09
EMU of resistance	ohm (Ω)	1.000 000*E−09
erg	joule (J)	1.000 000*E−07
erg/cm²·s	watt per square metre (W/m²)	1.000 000*E−03
erg/s	watt (W)	1.000 000*E−07
ESU of capacitance	farad (F)	1.112 650 E−12
ESU of current	ampere (A)	3.335 6 E−10
ESU of electric potential	volt (V)	2.997 9 E+02
ESU of inductance	henry (H)	8.987 554 E+11
ESU of resistance	ohm (Ω)	8.987 554 E+11
faraday (based on carbon-12)	coulomb (C)	9.648 70 E+04
faraday (chemical)	coulomb (C)	9.649 57 E+04
faraday (physical)	coulomb (C)	9.652 19 E+04
fathom	metre (m)	1.828 8 E+00
fermi (femtometre)	metre (m)	1.000 000*E−15
fluid ounce (U.S.)	cubic metre (m³)	2.957 353 E−05
foot	metre (m)	3.048 000*E−01

Table C-1 *(cont.)*

To convert from	*to*	*Multiply by*
foot (U.S. survey)	metre (m)	3.048 006 E−01
foot of water (39.2°F)	pascal (Pa)	2.988 98 E+03
ft^2	square metre (m^2)	9.290 304*E−02
ft^2/h (thermal diffusivity)	metre squared per second (m^2/s)	2.580 640*E−05
ft^2/s	metre squared per second (m^2/s)	9.290 304*E−02
ft^3 (volume; section modulus)	cubic metre (m^3)	2.831 685 E−02
ft^3/min	cubic metre per second (m^3/s)	4.719 474 E−04
ft^3/s	cubic metre per second (m^3/s)	2.831 685 E−02
ft^4 (moment of section)	metre to the fourth power (m^4)	8.630 975 E−03
ft·lbf	joule (J)	1.355 818 E+00
ft·lbf/h	watt (W)	3.766 161 E−04
ft·lbf/min	watt (W)	2.259 697 E−02
ft·lbf/s	watt (W)	1.355 818 E+00
ft·poundal	joule (J)	4.214 011 E−02
free fall, standard (g)	metre per second squared (m/s^2)	9.806 650*E+00
ft/h	metre per second (m/s)	8.466 667 E−05
ft/min	metre per second (m/s)	5.080 000*E−03
ft/s	metre per second (m/s)	3.048 000*E−01
ft/s^2	metre per second squared (m/s^2)	3.048 000*E−01
footcandle	lux (lx)	1.076 391 E+01
footlambert	candela per square metre (cd/m^2)	3.426 259 E+00
gal	metre per second squared (m/s^2)	1.000 000*E−02
gallon (Canadian liquid)	cubic metre (m^3)	4.546 090 E−03
gallon (U.K. liquid)	cubic metre (m^3)	4.546 092 E−03
gallon (U.S. dry)	cubic metre (m^3)	4.404 884 E−03
gallon (U.S. liquid)	cubic metre (m^3)	3.785 412 E−03
gal (U.S. liquid)/day	cubic metre per second (m^3/s)	4.381 264 E−08
gal (U.S. liquid)/min	cubic metre per second (m^3/s)	6.309 020 E−05
gal (U.S. liquid)/hp·h (SFC, specific fuel consumption)	cubic metre per joule (m^3/J)	1.410 089 E−09
gamma	tesla (T)	1.000 000*E−09
gauss	tesla (T)	1.000 000*E−04
gilbert	ampere (A)	7.957 747 E−01
grad	degree (angular)	9.000 000*E−01
grad	radian (rad)	1.570 796 E−02
gram	kilogram (kg)	1.000 000*E−03
g/cm^3	kilogram per cubic metre (kg/m^3)	1.000 000*E+03
gram-force/cm^2	pascal (Pa)	9.806 650*E+01
hectare	square metre (m^2)	1.000 000*E+04
horsepower (550 ft·lbf/s)	watt (W)	7.456 999 E+02
horsepower (electric)	watt (W)	7.460 000*E+02
horsepower (metric)	watt (W)	7.354 99 E+02
horsepower (water)	watt (W)	7.460 43 E+02
horsepower (U.K.)	watt (W)	7.457 0 E+02
hour (mean solar)	second (s)	3.600 000 E+03
hour (sidereal)	second (s)	3.590 170 E+03
hundredweight (long)	kilogram (kg)	5.080 235 E+01
hundredweight (short)	kilogram (kg)	4.535 924 E+01

Table C-1 *(cont.)*

To convert from	*to*	*Multiply by*
inch	metre (m)	2.540 000*E−02
inch of mercury (32°F)	pascal (Pa)	3.386 38 E+03
inch of mercury (60°F)	pascal (Pa)	3.376 85 E+03
inch of water (39.2°F)	pascal (Pa)	2.490 82 E+02
inch of water (60°F)	pascal (Pa)	2.488 4 E+02
in^2	square metre (m^2)	6.451 600*E−04
in^3 (volume; section modulus)	cubic metre (m^3)	1.638 706 E−05
in^3/min	cubic metre per second (m^3/s)	2.731 177 E−07
in^4 (moment of section)	metre to the fourth power (m^4)	4.162 314 E−07
in/s	metre per second (m/s)	2.540 000*E−02
in/s^2	metre per second squared (m/s^2)	2.540 000*E−02
kilocalorie (International Table)	joule (J)	4.186 800*E+03
kilocalorie (mean)	joule (J)	4.190 02 E+03
kilocalorie (thermochemical)	joule (J)	4.184 000*E+03
kilocalorie (thermochemical)/min	watt (W)	6.973 333 E+01
kilocalorie (thermochemical)/s	watt (W)	4.184 000*E+03
kilogram-force (kgf)	newton (N)	9.806 650*E+00
kgf·m	newton metre (N·m)	9.806 650*E+00
$kgf \cdot s^2/m$ (mass)	kilogram (kg)	9.806 650*E+00
kgf/cm^2	pascal (Pa)	9.806 650*E+04
kgf/m^2	pascal (Pa)	9.806 650*E+00
kgf/mm^2	pascal (Pa)	9.806 650*E+06
km/h	metre per second (m/s)	2.777 778 E−01
kilopond	newton (N)	9.806 650*E+00
kW·h	joule (J)	3.600 000*E+06
kip (1 000 lbf)	newton (N)	4.448 222 E+03
kip/in^2 (ksi)	pascal (Pa)	6.894 757 E+06
knot (international)	metre per second (m/s)	5.144 444 E−01
lambert	candela per square metre (cd/m^2)	$1/\pi$ *E+04
lambert	candela per square metre (cd/m^2)	3.183 099 E+03
langley	joule per square metre (J/m^2)	4.184 000*E+04
$lb \cdot ft^2$ (moment of inertia)	kilogram metre squared ($kg \cdot m^2$)	4.214 011 E−02
$lb \cdot in^2$ (moment of inertia)	kilogram metre squared ($kg \cdot m^2$)	2.926 397 E−04
lb/ft·h	pascal second (Pa·s)	4.133 789 E−04
lb/ft·s	pascal second (Pa·s)	1.488 164 E+00
lb/ft^2	kilogram per square metre (kg/m^2)	4.882 428 E+00
lb/ft^3	kilogram per cubic metre (kg/m^3)	1.601 846 E+01
lb/gal (U.K. liquid)	kilogram per cubic metre (kg/m^3)	9.977 633 E+01
lb/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	1.198 264 E+02
lb/h	kilogram per second (kg/s)	1.259 979 E−04
lb/hp·h (SFC, specific fuel consumption)	kilogram per joule (kg/J)	1.689 659 E−07
lb/in^3	kilogram per cubic metre (kg/m^3)	2.767 990 E+04
lb/min	kilogram per second (kg/s)	7.559 873 E−03
lb/s	kilogram per second (kg/s)	4.535 924 E−01
lb/yd^3	kilogram per cubic metre (kg/m^3)	5.932 764 E−01
lbf·ft	newton metre (N·m)	1.355 818 E+00
lbf·ft/in	newton metre per metre (N·m/m)	5.337 866 E+01

Table C-1 *(cont.)*

To convert from	*to*	*Multiply by*
lbf·in	newton metre (N·m)	1.129 848 E−01
lbf·in/in	newton metre per metre (N·m/m)	4.448 222 E+00
lbf·s/ft²	pascal second (Pa·s)	4.788 026 E+01
lbf/ft	newton per metre (N/m)	1.459 390 E+01
lbf/ft²	pascal (Pa)	4.788 026 E+01
lbf/in	newton per metre (N/m)	1.751 268 E+02
lbf/in² (psi)	pascal (Pa)	6.894 757 E+03
lbf/lb (thrust/weight (mass) ratio)	newton per kilogram (N/kg)	9.806 650 E+00
light year	metre (m)	9.460 55 E+15
litre	cubic metre (m³)	1.000 000*E−03
maxwell	weber (Wb)	1.000 000*E−08
mho	siemens (S)	1.000 000*E+00
microinch	metre (m)	2.540 000*E−08
micron	metre (m)	1.000 000*E−06
mil	metre (m)	2.540 000*E−05
mile (international)	metre (m)	1.609 344*E+03
mile (statute)	metre (m)	1.609 3 E+03
mile (U.S. survey)	metre (m)	1.609 347 E+03
mile (international nautical)	metre (m)	1.852 000*E+03
mile (U.K. nautical)	metre (m)	1.853 184*E+03
mile (U.S. nautical)	metre (m)	1.852 000*E+03
mi² (international)	square metre (m²)	2.589 988 E+06
mi² (U.S. survey)	square metre (m²)	2.589 998 E+06
mi/h (international)	metre per second (m/s)	4.470 400*E−01
mi/h (international)	kilometre per hour (km/h)	1.609 344*E+00
mi/min (international)	metre per second (m/s)	2.682 240*E+01
mi/s (international)	metre per second (m/s)	1.609 344*E+03
millibar	pascal (Pa)	1.000 000*E+02
millimetre of mercury (0°C)	pascal (Pa)	1.333 22 E+02
minute (angle)	radian (rad)	2.908 882 E−04
minute (mean solar)	second (s)	6.000 000 E+01
minute (sidereal)	second (s)	5.983 617 E+01
month (mean calendar)	second(s)	2.628 000 E+06
oersted	ampere per metre (A/m)	7.957 747 E+01
ohm centimetre	ohm metre (Ω·m)	1.000 000*E−02
ohm circular-mil per ft	ohm millimetre squared per metre (Ω·mm²/m)	1.662 426 E−03
ounce (avoirdupois)	kilogram (kg)	2.834 952 E−02
ounce (troy or apothecary)	kilogram (kg)	3.110 348 E−02
ounce (U.K. fluid)	cubic metre (m³)	2.841 307 E−05
ounce (U.S. fluid)	cubic metre (m³)	2.957 353 E−05
ounce-force	newton (N)	2.780 139 E−01
ozf·in	newton metre (N·m)	7.061 552 E−03
oz (avoirdupois)/gal (U.K. liquid)	kilogram per cubic metre (kg/m³)	6.236 021 E+00
oz (avoirdupois)/gal (U.S. liquid)	kilogram per cubic metre (kg/m³)	7.489 152 E+00
oz (avoirdupois)/in³	kilogram per cubic metre (kg/m³)	1.729 994 E+03
oz (avoirdupois)/ft²	kilogram per square metre (kg/m²)	3.051 517 E−01
oz (avoirdupois)/yd²	kilogram per square metre (kg/m²)	3.390 575 E−02

Table C-1 *(cont.)*

To convert from	*to*	*Multiply by*
parsec	metre (m)	3.085 678 E + 16
pennyweight	kilogram (kg)	1.555 174 E − 03
perm (0°C)	kilogram per pascal second metre squared (kg/Pa·s·m²)	5.721 35 E − 11
perm (23°C)	kilogram per pascal second metre squared (kg/Pa·s·m²)	5.745 25 E − 11
perm·in (0°C)	kilogram per pascal second metre (kg/Pa·s·m)	1.453 22 E − 12
perm·in (23°C)	kilogram per pascal second metre (kg/Pa·s·m)	1.459 29 E − 12
phot	lumen per square metre (lm/m²)	1.000 000*E + 04
pint (U.S. dry)	cubic metre (m³)	5.506 105 E − 04
pint (U.S. liquid)	cubic metre (m³)	4.731 765 E − 04
poise (absolute viscosity)	pascal second (Pa·s)	1.000 000*E − 01
pound (lb avoirdupois)	kilogram (kg)	4.535 924 E − 01
pound (troy or apothecary)	kilogram (kg)	3.732 417 E − 01
poundal	newton (N)	1.382 550 E − 01
poundal/ft²	pascal (Pa)	1.488 164 E + 00
poundal·s/ft²	pascal second (Pa·s)	1.488 164 E + 00
pound-force (lbf)	newton (N)	4.448 222 E + 00
quart (U.S. dry)	cubic metre (m³)	1.101 221 E − 03
quart (U.S. liquid)	cubic metre (m³)	9.463 529 E − 04
rad (radiation dose absorbed)	gray (Gy)	1.000 000*E − 02
rem	sievert (Sv)	1.000 000*E − 02
rhe	1 per pascal second (1/Pa·s)	1.000 000*E + 01
roentgen	coulomb per kilogram (C/kg)	2.58 E − 04
second (angle)	radian (rad)	4.848 137 E − 06
second (sidereal)	second (s)	9.972 696 E − 01
slug	kilogram (kg)	1.459 390 E + 01
slug/ft·s	pascal second (Pa·s)	4.788 026 E + 01
slug/ft³	kilogram per cubic metre (kg/m³)	5.153 788 E + 02
statampere	ampere (A)	3.335 640 E − 10
statcoulomb	coulomb (C)	3.335 640 E − 10
statfarad	farad (F)	1.112 650 E − 12
stathenry	henry (H)	8.987 554 E + 11
statmho	siemens (S)	1.112 650 E − 12
statohm	ohm (Ω)	8.987 554 E + 11
statvolt	volt (V)	2.997 925 E + 02
stere	cubic metre (m³)	1.000 000*E + 00
stilb	candela per square metre (cd/m²)	1.000 000*E + 04
stokes (kinematic viscosity)	metre squared per second (m²/s)	1.000 000*E − 04
therm	joule (J)	1.055 056 E + 08
ton (assay)	kilogram (kg)	2.916 667 E − 02
ton (long, 2 240 lb)	kilogram (kg)	1.016 047 E + 03
ton (metric)	kilogram (kg)	1.000 000*E + 03
ton (nuclear equivalent of TNT)	joule (J)	4.184 E + 09
ton (refrigeration)	watt (W)	3.516 800 E + 03

Table C-1 *(cont.)*

To convert from	*to*	*Multiply by*
ton (register)	cubic metre (m^3)	2.831 685 E+00
ton (short, 2 000 lb)	kilogram (kg)	9.071 847 E+02
ton (long)/yd^3	kilogram per cubic metre (kg/m^3)	1.328 939 E+03
ton (short)/h	kilogram per second (kg/s)	2.519 958 E−01
ton-force (2 000 lbf)	newton (N)	8.896 444 E+03
tonne	kilogram (kg)	1.000 000*E+03
torr (mm Hg, 0°C)	pascal (Pa)	1.333 22 E+02
unit pole	weber (Wb)	1.256 637 E−07
W·h	joule (J)	3.600 000*E+03
W·s	joule (J)	1.000 000*E+00
W/cm^2	watt per square metre (W/m^2)	1.000 000*E+04
W/in^2	watt per square metre (W/m^2)	1.550 003 E+03
yard	metre (m)	9.144 000*E−01
yd^2	square metre (m^2)	8.361 274 E−01
yd^3	cubic metre (m^3)	7.645 549 E−01
yd^3/min	cubic metre per second (m^3/s)	1.274 258 E−02
year (calendar)	second (s)	3.153 600 E+07
year (sidereal)	second (s)	3.155 815 E+07
year (tropical)	second (s)	3.155 693 E+07

Table C-2. Temperature conversion formulae

To convert from	*to*	*Use formula*
Celsius temperature ($t_{°C}$)	Kelvin temperature (t_K)	$t_K = t_{°C} + 273.15$
Fahrenheit temperature ($t_{°F}$)	Celsius temperature ($t_{°C}$)	$t_{°C} = (t_{°F} - 32)/1.8$
Fahrenheit temperature ($t_{°F}$)	Kelvin temperature (t_K)	$t_K = (t_{°F} + 459.67)/1.8$
Kelvin temperature (t_K)	Celsius temperature ($t_{°C}$)	$t_{°C} = t_K - 273.15$
Rankine temperature ($t_{°R}$)	Kelvin temperature (t_K)	$t_K = t_{°R}/1.8$

ATTACHMENT D. CO-ORDINATED UNIVERSAL TIME

1. Co-ordinated Universal Time (UTC) has now replaced Greenwich Mean Time (GMT) as the accepted international standard for clock time. It is the basis for civil time in many States and is also the time used in the world-wide time signal broadcasts used in aviation. The use of UTC is recommended by such bodies as the General Conference on Weights and Measures (CGPM), the International Radio Consultative Committee (CCIR) and the World Administration Radio Conference (WARC).

2. The basis for all clock time is the time of apparent rotation of the sun. This is, however, a variable quantity which depends, among other things, on where it is measured on earth. A mean value of this time, based upon measurements in a number of places on the earth, is known as Universal Time. A different time scale, based upon the definition of the second, is known as International Atomic Time (TAI). A combination of these two scales results in Co-ordinated Universal Time. This consists of TAI adjusted as necessary by the use of leap seconds to obtain a close approximation (always within 0.5 seconds) of Universal Time.

ATTACHMENT E. PRESENTATION OF DATE AND TIME IN ALL-NUMERIC FORM

1. Introduction

The International Organization for Standardization (ISO) Standards 2014 and 3307 specify the procedures for writing the date and time in all-numeric form and ICAO will be using these procedures in its documents where appropriate in the future.

2. Presentation of Date

Where dates are presented in all-numeric form, IS0 2014 specifies that the sequence year-month-day should be used. The elements of the date should be:

- four digits to represent the year, except that the century digits may be omitted where no possible confusion could arise from such an omission. There is value in using the century digits during the period of familiarization with the new format to make it clear that the new order of elements is being used;
- two digits to represent the month;
- two digits to represent the day. Where it is desired to separate the elements for easier visual understanding, only a space or a hyphen should be used as a separator. As an example, 25 August 1983 may be written as:

19830825 or 830825

Or 1983-08-25 or 83-08-25

Or 1983 08 25 or 83 08 25

should be emphasized that the IS0 sequence should only be used where it is intended to use an all-numeric presentation. Presentations using a combination of figures and words may still be used if required (e.g. 25 August 1983).

3. Presentation of Time

3.1 Where the time of day is to be written in all-numeric form, IS0 3307 specifies that the sequence hours-minutes-seconds should be used.

3.2 Hours should be represented by two digits from 00 to 23 in the 24-hour timekeeping system and may be followed either by decimal fractions of an hour or by minutes and seconds. Where decimal fractions of an hour are used, the normal decimal separator should be used followed by the number of digits necessary to provide the required accuracy.

3.3 Minutes should likewise be represented by two digits from 00 to 59 followed by either decimal fractions of a minute or by seconds.

3.4 Seconds should also be represented by two digits from 00 to 59 and followed by decimal fractions of a second if required.

3.5 Where it is necessary to facilitate visual understanding a colon should be used to separate hours and minutes and minutes and seconds. For example, 20 minutes and 18 seconds past 3 o'clock in the afternoon may be written as:

152018 or 15:20:18 in hours, minutes and seconds *or* 1520.3 or 15:20.3 in hours, minutes and decimal fractions of a minute *or* 15.338 in hours and decimal fractions of an hour.

4. Combination Date and Time Groups

This presentation lends itself to a uniform method of writing date and time together where necessary. In such cases, the sequence of elements year-month-day-hour-minute-second should be used. It may be noted that not all the elements need be used in every case - in a typical application, for example, only the elements day-hour-minute might be used.

- END -