GOVERNMENT OF INDIA

OFFICE OF DIRECTOR GENERAL OF CIVIL AVIATION

TECHNICAL CENTRE, OPP SAFDARJANG AIRPORT, NEW DELHI

CIVIL AVIATION REQUIREMENTS
SECTION 1- GENERAL
SERIES 'B', PART I
19th SEPTEMBER, 2005 EFFECTIVE: FORTHWITH

Subject : **Units of Measurements to be used in air and ground operations.**

INTRODUCTION

Article 28 (Air navigation facilities and standard systems) of the Convention on International Civil Aviation requires each contracting State to provide, in its territory, airports, radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention. ICAO Annex 5 provides the Standards and Recommended Practices pertaining to the units and measurements to be used in Air and Ground operations which are required to be adopted by the Contracting State. Accordingly, this CAR is issued under the provisions of Rule 29C and Rule 133A of the Aircraft Rules, 1937.

1. DEFINITIONS

When the following terms are used in the CAR, they have the following meanings:

Ampere (A). The ampere is that constant electric current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2 x 10 -7 newton per metre of length.

Becquerel (Bq). The activity of a radionuclide having one spontaneous nuclear transition per second.

Candela (cd). The luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square metre of black body at the temperature of freezing platinum under a pressure of 101 325 newtons per square metre.

Celsius temperature ($t°_C$). The Celsius temperature is equal to the difference $t°_C = T - T_0$ between two thermodynamic temperatures T and T_0 where T_0 equals 273.15 kelvin.

Coulomb (C). The quantity of electricity transported in 1 second by a current of 1 ampere.

Degree Celsius (°C). The special name for the unit kelvin for use in stating values of Celsius temperature.

Farad (F). The capacitance of a capacitor between the plates of which there appears a difference of potential of 1 volt when it is charged by a quantity of electricity equal to 1 coulomb.

Foot (ft). The length equal to 0.304 8 metre exactly.

Gray (Gy). The energy imparted by ionizing radiation to a mass of matter corresponding to 1 joule per kilogram.

Henry (H). The inductance of a closed circuit in which an electromotive force of 1 volt is produced when the electric current in the circuit varies uniformly at a rate of 1 ampere per second.

Hertz (Hz). The frequency of a periodic phenomenon of which the period is 1 second.

Human performance. Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

Joule (J). The work done when the point of application of a force of 1 newton is displaced a distance of 1 metre in the direction of the force.

Kelvin (K). A unit of thermodynamic temperature which is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

Kilogram (kg). The unit of mass equal to the mass of the international prototype of the kilogram.

Knot (kt). The speed equal to 1 nautical mile per hour.

Litre (L). A unit of volume restricted to the measurement of liquids and gases which is equal to 1 cubic decimetre.

Lumen (lm). The luminous flux emitted in a solid angle of 1 steradian by a point source having a uniform intensity of 1 candela.

Lux (/x). The illuminance produced by a luminous flux of 1 lumen uniformly distributed over a surface of 1 square metre.

Metre (m). The distance travelled by light in a vacuum during 1/299 792 458 of a second.

Mole (mol). The amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12.

Note.-- When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles or specified groups of such particles.

Nautical mile (NM). The length equal to 1 852 metres exactly. Newton (N). The force which when applied to a body having a mass of 1 kilogram gives it an acceleration of 1 metre per second squared.

Ohm (Ω). The electric resistance between two points of a conductor when a constant difference of potential of 1 volt, applied between these two points, produces in this conductor a current of 1 ampere, this conductor not being the source of any electromotive force.

Pascal (Pa). The pressure or stress of 1 newton per square metre.

Radian (rad). The plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.

Second (s). The duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium- 133 atom.

Siemens (S). The electric conductance of a conductor in which a current of 1 ampere is produced by an electric potential difference of 1 volt.

Sievert (Sv). The unit of radiation dose equivalent corresponding to 1 joule per kilogram.

Steradian (sr). The solid angle which, having its vertex in the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

Tesla (T). The magnetic flux density given by a magnetic flux of 1 weber per square metre.

Tonne (t). The mass equal to 1 000 kilograms.

Volt (V). The unit of electric potential difference and electromotive force which is the difference of electric potential between two points of a conductor carrying a constant current of 1 ampere, when the power dissipated between these points is equal to 1 watt.

Watt (W). The power which gives rise to the production of energy at the rate of 1 joule per second.

Weber (Wb). The magnetic flux which, linking a circuit of one turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in 1 second.

2. REQUIREMENTS

The units as given in Table 2.1 shall be used for all aspects of air and ground operations.

Table 2-1. Units of Measurement

Ref. No.	*Quantity*	*Unit to be used (symbol)*
1. Direction/Space/Time		
1.1	altitude	ft
1.2	area	M^2
1.3	distance (long)[a)]	NM
1.4	distance (short)	M
1.5	elevation	ft
1.6	endurance	h and min
1.7	height	ft
1.8	latitude	° ' "
1.9	length	m
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	m³
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)	º

2. Mass-related

2.1	air density	kg/m³
2.2	area density	kg/m²
2.3	cargo capacity	kg
2.4	cargo density	kg/m³
2.5	density (mass density)	kg/m³
2.6	fuel capacity (gravimetric)	kg
2.7	gas density	kg/m³
2.8	gross mass or payload	kg
		T
2.9	hoisting provisions	kg
2.10	linear density	kg/m
2.11	liquid density	kg/m³
2.12	mass	kg
2.13	moment of inertia	kg · m²
2.14	moment of momentum	kg · m²/s
2.15	momentum	kg · m/s

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
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)]	kt
4.2	angular acceleration	rad/s²
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	kt
4.8	impact	J/m²
4.9	kinetic energy absorbed by brakes	MJ
4.10	linear acceleration	m/s²
4.11	power	kW
4.12	rate of trim	º/s
4.13	shaft power	kW
4.14	velocity	m/s
4.15	vertical speed	ft/min
4.16	wind speed [e)]	m/s, 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)
	turbo-shaft engines	kg/(kW.h)
	jet engines	kg/(kN.h)
5.4	fuel flow	kg/h
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
	piston engines (specific)	g/kW.h)
5.11	oil flow	g/s
5.12	pump capacity	L/min
5.13	ventilation air flow	m³/min
5.14	viscosity (dynamic)	Pa · s

5.15	viscosity (kinematic)	m^2/s

6. Thermodynamics

6.1	coefficient of heat transfer	$W/(m^2.K)$
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	$^oC^{-1}$
6.6	quantity of heat	J
6.7	temperature	^oC

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.s
8.7	radiant energy	J
8.8	wavelength	m

9. Acoustics

9.1	frequency	Hz

9.2	mass density	Kg/m³
9.3	noise level	dB*
9.4	period, periodic time	s
9.5	sound intensity	W/ m²
9.6	sound power	W
9.7	sound pressure	Pa
9.8	sound level	DB [f]
9.9	static pressure (instantaneous)	Pa
9.10	velocity of sound	m/s
9.11	volume velocity (instantaneous)	m³/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 4000m.
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) A conversion of 1 kt = 0.5 m/s is used for the representation of wind speed.
f) 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.

Table 2-2. Unit prefixes

Multiplication factor	*Prefix*	*Symbol*
1 000000000000000000 = 10^{18}	exa	E
1 000000000000000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000000000 = 10^{9}	giga	G
1 000000 = 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 =	centi	c
0.001 = 10^{-3}	Milli	m
0.000 001 = 10^{-6}	Micro	g
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

Table 2-3 Additional units for use with the above units

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	º	1º = (π/180) rad
	minute	'	1' = (1/60)º = (π/10 800) rad
	second	"	1" = (1/60)' = (π/648 000) rad
temperature	degree Celsius	ºC	1 unit ºC = 1 unit K[a)]
time	minute	min	1 min = 60 s
	hour	h	1 h = 60 min = 3600 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 Table below for conversion

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)	$t_K = t°_R/1.8$

Distance/ speed conversion formulae

(altitude, elevation, height, vertical speed)

To convert from	***To***	***Use formulae***
Nautical Mile (NM)	Meter (m)	1 NM = 1852 m
Foot (ft)	Meter (m)	1 ft = 0.3048 m
Knot (kt)	Meter/second (m/s)	1 kt = 0.514 444 m/s

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