

CHAPTER 37

UNITS AND CONVERSIONS

Table 1 Conversions to SI Units

Multiply	By	To Obtain	Multiply	By	To Obtain
acre.....	0.4047	ha	in ²	645.2	mm ²
atmosphere (standard)	*101.325	kPa	in ³ (volume).....	16.4	mL
bar.....	*100	kPa	in ³ /min (SCIM).....	0.273	mL/s
barrel (42 U.S. gal, petroleum).....	159.0	L	in ³ (section modulus).....	16,390	mm ³
	0.1590	m ³	in ⁴ (section moment).....	416,200	mm ⁴
Btu (International Table).....	1.055	kJ	km/h.....	0.2778	m/s
Btu/ft ²	11.36	kJ/m ²	kWh.....	*3.60	MJ
Btu/ft ³	37.3	kJ/m ³	kW/1000 cfm.....	2.12	kJ/m ³
Btu/gal.....	279	kJ/m ³	kilopond (kg force).....	9.81	N
Btu · ft/h · ft ² · °F.....	1.731	W/(m · K)	kip (1000 lb _f).....	4.45	kN
Btu · in/h · ft ² · °F (thermal conductivity, <i>k</i>).....	0.1442	W/(m · K)	kip/in ² (ksi).....	6.895	MPa
Btu/h.....	0.2931	W	litre.....	*0.001	m ³
Btu/h · ft ²	3.155	W/m ²	met.....	58.15	W/m ²
Btu/h · ft ² · °F			micron (μm) of mercury (60°F).....	133	mPa
(overall heat transfer coefficient, <i>U</i>).....	5.678	W/(m ² · K)	mile.....	1.609	km
Btu/lb.....	*2.326	kJ/kg	mile, nautical.....	*1.852	km
Btu/lb · °F (specific heat, <i>c_p</i>).....	4.184	kJ/(kg · K)	mph.....	1.609	km/h
bushel.....	0.03524	m ³		0.447	m/s
calorie, gram.....	4.184	J	millibar.....	*0.100	kPa
calorie, kilogram (kilocalorie).....	4.184	kJ	mm of mercury (60°F).....	0.133	kPa
centipoise (dynamic viscosity, μ).....	*1.00	mPa · s	mm of water (60°F).....	9.80	Pa
centistokes (kinematic viscosity, ν).....	*1.00	mm ² /s	ounce (mass, avoirdupois).....	28.35	g
clo.....	0.155	m ² · K/W	ounce (force or thrust).....	0.278	N
dyne/cm ²	*0.100	Pa	ounce (liquid, U.S.).....	29.6	mL
EDR hot water (150 Btu/h).....	44.0	W	ounce inch (torque, moment).....	7.06	mN · m
EDR steam (240 Btu/h).....	70.3	W	ounce (avoirdupois) per gallon.....	7.49	kg/m ³
EER.....	0.293	COP	perm (permeance).....	57.45	ng/(s · m ² · Pa)
ft.....	*0.3048	m	perm inch (permeability).....	1.46	ng/(s · m · Pa)
	*304.8	mm	pint (liquid, U.S.).....	473	mL
ft/min, fpm.....	*0.00508	m/s	pound		
ft/s, fps.....	*0.3048	m/s	lb (mass).....	0.4536	kg
ft of water.....	2.99	kPa		453.6	g
ft of water per 100 ft pipe.....	0.0981	kPa/m	lb _f (force or thrust).....	4.448	N
ft ²	0.09290	m ²	lb/ft (uniform load).....	1.49	kg/m
ft ² · h · °F/Btu (thermal resistance, <i>R</i>).....	0.176	m ² · K/W	lb _m /ft · h (dynamic viscosity, μ).....	0.4134	mPa · s
ft ² /s (kinematic viscosity, ν).....	92,900	mm ² /s	lb _m /ft · s (dynamic viscosity, μ).....	1490	mPa · s
ft ³	28.32	L	lb _f · s/ft ² (dynamic viscosity, μ).....	47.88	Pa · s
	0.02832	m ³	lb/h.....	0.126	g/s
ft ³ /min, cfm.....	0.4719	L/s	lb/min.....	0.00756	kg/s
ft ³ /s, cfs.....	28.32	L/s	lb/h [steam at 212°F (100°C)].....	0.2843	kW
ft · lb _f (torque or moment).....	1.356	N · m	lb _f /ft ²	47.9	Pa
ft · lb _f (work).....	1.356	J	lb/ft ²	4.88	kg/m ²
ft · lb _f /lb (specific energy).....	2.99	J/kg	lb/ft ³ (density, ρ).....	16.0	kg/m ³
ft · lb _f /min (power).....	0.0226	W	lb/gallon.....	120	kg/m ³
footcandle.....	10.76	lx	ppm (by mass).....	*1.00	mg/kg
gallon (U.S., *231 in ³).....	3.7854	L	psi.....	6.895	kPa
gph.....	1.05	mL/s	quad (10 ¹⁵ Btu).....	1.055	EJ
gpm.....	0.0631	L/s	quart (liquid, U.S.).....	0.9463	L
gpm/ft ²	0.6791	L/(s · m ²)	square (100 ft ²).....	9.29	m ²
gpm/ton refrigeration.....	0.0179	mL/J	tablespoon (approximately).....	15	mL
grain (1/7000 lb).....	0.0648	g	teaspoon (approximately).....	5	mL
gr/gal.....	17.1	g/m ³	therm (U.S.).....	105.5	MJ
gr/lb.....	0.143	g/kg	ton, long (2240 lb).....	1.016	Mg
horsepower (boiler) (33,470 Btu/h).....	9.81	kW	ton, short (2000 lb).....	0.907	Mg; t (tonne)
horsepower (550 ft · lb _f /s).....	0.7457	kW	ton, refrigeration (12,000 Btu/h).....	3.517	kW
inch.....	*25.4	mm	torr (1 mm Hg at 0°C).....	133	Pa
in. of mercury (60°F).....	3.37	kPa	watt per square foot.....	10.76	W/m ²
in. of water (60°F).....	249	Pa	yd.....	*0.9144	m
in/100 ft, thermal expansion.....	0.833	mm/m	yd ²	0.8361	m ²
in · lb _f (torque or moment).....	113	mN · m	yd ³	0.7646	m ³
To Obtain	By	Divide	To Obtain	By	Divide

*Conversion factor is exact.

Notes: Units are U.S. values unless noted otherwise.

Litre is a special name for the cubic decimetre. 1 L = 1 dm³ and 1 mL = 1 cm³.

Table 2 Conversion Factors

Pressure psi	in. of water (60°F)	in. Hg (32°F)	atmosphere	mm Hg (32°F)	bar	kgf/cm ²	pascal
1	= 27.708	= 2.0360	= 0.068046	= 51.715	= 0.068948	= 0.07030696	= 6894.8
0.036091	1	0.073483	2.4559×10^{-3}	1.8665	2.4884×10^{-3}	2.537×10^{-3}	248.84
0.491154	13.609	1	0.033421	25.400	0.033864	0.034532	3386.4
14.6960	407.19	29.921	1	760.0	1.01325*	1.03323	1.01325×10^5 *
0.0193368	0.53578	0.03937	1.31579×10^{-3}	1	1.3332×10^{-3}	1.3595×10^{-3}	133.32
14.5038	401.86	29.530	0.98692	750.062	1	1.01972*	10 ⁵ *
14.223	394.1	28.959	0.96784	735.559	0.980665*	1	9.80665×10^4 *
1.45038×10^{-4}	4.0186×10^{-3}	2.953×10^{-4}	9.8692×10^{-6}	7.50×10^{-3}	10 ⁻⁵ *	1.01972×10^{-5} *	1

Mass	lb (avoird.)	grain	ounce (avoird.)	kg
1	1	= 7000*	= 16*	= 0.45359
	1.4286×10^{-4}	1	2.2857×10^{-3}	6.4800×10^{-5}
	0.06250	437.5*	1	0.028350
	2.20462	1.5432×10^4	35.274	1

Volume	cubic inch	cubic foot	gallon	litre	cubic metre (m ³)
1	1	= 5.787×10^{-4}	= 4.329×10^{-3}	= 0.0163871	= 1.63871×10^{-5}
1728*	1728*	1	7.48052	28.317	0.028317
231.0*	231.0*	0.13368	1	3.7854	0.0037854
61.02374	61.02374	0.035315	0.264173	1	0.001*
6.102374×10^4	6.102374×10^4	35.315	264.173	1000*	1

Energy	Btu	ft·lb _f	calorie (cal)	joule (J) = watt-second (W·s)	watt-hour (W·h)
1	1	= 778.17	= 251.9958	= 1055.056	= 0.293071
Note: MBtu, which is 1000 Btu, is confusing and is not used in the Handbook.	1.2851×10^{-3}	1	0.32383	1.355818	3.76616×10^{-4}
	3.9683×10^{-3}	3.08803	1	4.1868*	1.163×10^{-3} *
	9.4782×10^{-4}	0.73756	0.23885	1	2.7778×10^{-4}
	3.41214	2655.22	859.85	3600*	1

Density	lb/ft ³	lb/gal	g/cm ³	kg/m ³
1	1	= 0.133680	= 0.016018	= 16.018463
7.48055	7.48055	1	0.119827	119.827
62.4280	62.4280	8.34538	1	1000*
0.0624280	0.0624280	0.008345	0.001*	1

Specific Volume	ft ³ /lb	gal/lb	cm ³ /g	m ³ /kg
1	1	= 7.48055	= 62.4280	= 0.0624280
0.133680	0.133680	1	8.34538	0.008345
0.016018	0.016018	0.119827	1	0.001*
16.018463	16.018463	119.827	1000*	1

Viscosity (absolute)	1 poise = 1 dyne-sec/cm ² = 0.1 Pa·s = 1 g/(cm·s)			
poise	lb _f ·s/ft ²	lb _f ·h/ft ²	kg/(m·s) = N·s/m ²	lb _m /ft·s
1	= 2.0885×10^{-3}	= 5.8014×10^{-7}	= 0.1*	= 0.0671955
478.8026	1	2.7778×10^{-4}	47.88026	32.17405
1.72369×10^6	3600*	1	1.72369×10^5	1.15827×10^5
10*	0.020885	5.8014×10^{-6}	1	0.0671955
14.8819	0.031081	8.6336×10^{-6}	1.4882	1

Temperature Scale	Temperature				Temperature Interval			
	K	°C	°R	°F	K	°C	°R	°F
Kelvin	x K = x	$x - 273.15$	$1.8x$	$1.8x - 459.67$	1 K = 1	1	9/5 = 1.8	9/5 = 1.8
Celsius	x °C = $x + 273.15$	x	$1.8x + 491.67$	$1.8x + 32$	1°C = 1	1	9/5 = 1.8	9/5 = 1.8
Rankine	x °R = $x/1.8$	$(x - 491.67)/1.8$	x	$x - 459.67$	1°R = 5/9	5/9	1	1
Fahrenheit	x °F = $(x + 459.67)/1.8$	$(x - 32)/1.8$	$x + 459.67$	x	1°F = 5/9	5/9	1	1

Notes: Conversions with * are exact. The Btu and calorie are based on the International Table.

All temperature conversions and factors are exact. The term centigrade is obsolete and should not be used.

When making conversions, remember that a converted value is no more precise than the original value. For many applications, rounding off the converted value to the same number of significant figures as those in the original value provides sufficient accuracy.

Caution: The conversion values in Table 1 are rounded to three or four significant figures, which is sufficiently accurate for most applications. See ANSI Standard SI-10 (available from ASTM or IEEE) for additional conversions with more significant figures.