SI Guide for HVAC&R

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This guide is based in large part on ANSI/IEEE/ASTM SI 10™-2010, *American National Standard for Metric Practice* (IEEE/ASTM 2011). See ANSI/IEEE/ASTM SI 10™-2010 for more information and a complete list of conversion factors with more significant digits.

ASHRAE UNITS POLICY

The following is excerpted from ASHRAE's Rules of the Board:

1.201.002 Units Policy

1.201.002.1 The units use or application policy shall include, as a minimum, time-dated directions on the use of SI and I-P in all ASHRAE publications.

1.201.002.2 TC 1.6 shall serve as the authority on SI and I-P usage and application.

1.201.002.3 Research projects; codes, standards, guidelines and addenda thereto; special publications; Insights articles; Journal articles; and Handbooks shall be prepared using the International System of Units (SI) and/or inch-pound units (I-P) in formats approved by the Publishing and Education Council.

1.201.002.4 The Publishing and Education Council shall review annually the approved formats to be used in ASHRAE publications, considering suggestions from members and committees, and shall establish any changes in the approved formats.

1.201.002.5 The Publishing and Education Council shall consider this Units Policy annually and shall recommend to the Board of Directors the formats to be used in ASHRAE publications.

A. The format for ASHRAE publications shall be dual units, except in cases determined by the Publishing and Education Council, where two separate versions are to be published, where one is rational SI and the other is rational I-P. For selected ASHRAE standards and guidelines, the Standards Committee may approve use of SI units only.

B. In dual unit publications, the units used in calculating the work being reported shall be listed first. The alternate system of units should follow in parentheses. Authors shall round off equivalents in the alternate system of units so that they imply the same accuracy as is implied with primary units.

C. Exceptions require the approval of the Director of Publishing and Education.

1.201.002.6 Handbook volumes shall be published in separate SI and I-P editions.

1.201.002.7 *HVAC&R Research*, as ASHRAE's international research journal, may publish papers in dual units or, in cases where the original research being reported was conducted in SI units, in SI units only.

SI PRACTICE

1 General

1.1 The International System of Units (SI) consists of seven base units listed in Table 1 and numerous derived units, which are combinations of base units (Table 2).

Table 1 SI Base Units

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

Table 2 Selected SI Derived Units

Quantity	Expression in Other SI Units	Name	Symbol
acceleration			
angular	rad/s^2		
linear	m/s^2		
angle			
plane	dimensionless	radian	rad
solid	dimensionless	steradian	sr
area	m^2		
Celsius temperature	K	degree Celsius	°C
conductivity, thermal	W/(m·K)		
density			
heat flux	W/m^2		
mass	kg/m^3		
energy, enthalpy			
work, heat	N·m	joule	J
specific	J/kg		
entropy			
heat capacity	J/K		
specific	J/(kg·K)		
flow, mass	kg/s		

Table 2 Selected SI Derived Units

Quantity	Expression in Other SI Units	Name	Symbol
flow, volume	m^3/s		
force	$kg·m/s^2$	newton	N
frequency			
periodic	1/s	hertz	Hz
rotating	rev/s		
inductance	Wb/A	henry	H
magnetic flux	V·s	weber	Wb
moment of a force	N·m		
potential, electric	W/A	volt	V
power, radiant flux	J/s	watt	W
pressure, stress	N/m^2	pascal	Pa
resistance, electric	V/A	ohm	Ω or O
velocity			
angular	rad/s		
linear	m/s		
viscosity			
dynamic (absolute) (m)	Pa·s		
kinematic (n)	m^2/s		
volume	m^3		
volume, specific	m^3/kg		

2 Units

2.1 In SI, each physical quantity has only one unit. The base and derived units may be modified by prefixes as indicated in Section 4. All derived units are formed as combinations of base units linked by the algebraic relations connecting the quantities represented. The basic simplicity of the system can only be kept by adhering to the approved units.

2.2 **Angle.** The unit of plane angle is the radian. The degree and its decimal fractions may be used, but the minute and second should not be used.

2.3 **Area.** The unit of area is the square metre. Large areas are expressed in hectares (ha) or square kilometres (km^2). The hectare is restricted to land or sea areas and equals 10 000 m^2.

2.4 **Energy.** The unit of energy, work, and quantity of heat is the joule (J). The kilowatthour (kWh) is presently allowed as an alternative in electrical applications, but should not be introduced in new applications.

1 kilowatthour (kWh) = 3.6 megajoules (MJ)

The unit of power and heat flow rate is the watt (W).

1 watt (W) = 1 joule per second (J/s)

2.5 **Force.** The unit of force is the newton (N). The newton is also used in derived units that include force.

Examples:

pressure or stress = N/m^2 = Pa (pascal)
work = N·m = J (joule)
power = N·m/s = W (watt)

2.6 **Length.** The unit of length is the metre. The millimetre is used on architectural or construction drawings and mechanical or shop drawings. The symbol mm does not need to be placed after each dimension; a note, "All dimensions in mm," is sufficient.

The centimetre is used only for cloth, clothing sizes, and anatomical measurements. The metre is used for topographical and plot plans. It is always written with a decimal and three figures following the decimal (e.g., 38.560).

2.7 **Mass.** The unit of mass is the kilogram (kg). The unit of mass is the only unit whose name, for historical reasons, contains a prefix. Names of multiples of the unit mass are formed by attaching prefixes to the word gram. The megagram, Mg (1000 kg, metric ton or tonne, t), is the appropriate unit for describing large masses. Do not use the term *weight* when *mass* is intended.

2.8 **Pressure.** The unit of stress or pressure, force per unit area, is the newton per square metre. This unit is called the *pascal* (Pa). SI has no equivalent symbol for psig or psia. If a misinterpretation is likely, spell out Pa (absolute) or Pa (gage).

2.9 **Volume.** The unit of volume is the cubic metre. Smaller units are the litre, L (m^3/1000); millilitre, mL; and microlitre, μL. No prefix other than m or μ is used with litre.

2.10 **Temperature.** The unit of thermodynamic (absolute) temperature is the Kelvin. Celsius temperature is measured in degrees Celsius. Temperature intervals may be measured in kelvins or degrees Celsius and are the same in either scale. Thermodynamic temperature is related to Celsius temperature as follows:

$$t_c = T - T_0$$

where

t_c = Celsius temperature, °C
T = thermodynamic temperature, kelvins (K)
T_0 = 273.15 K by definition

2.11 **Time.** The unit of time is the second, which should be used in technical calculations. However, where time relates to life customs or calendar cycles, the minute, hour, day, and other calendar units may be necessary.

Exception: Revolutions per minute may be used, but revolutions per second is preferred.

3 Symbols

3.1 The correct use of symbols is important because an incorrect symbol may change the meaning of a quantity. Some SI symbols are listed in Table 3.

Table 3 SI Symbols

Symbol	Name	Quantity	Formula
A	ampere	electric current	base unit
a	atto	prefix	10^{-18}
Bq	becquerel	activity (of a radionuclide)	1/s
C	coulomb	quantity of electricity	A·s
°C	degree Celsius	temperature	°C = K
c	centi	prefix	10^{-2}
cd	candela	luminous intensity	base unit
d	deci	prefix	10^{-1}
da	deka	prefix	10^{1}
E	exa	prefix	10^{18}
F	farad	electric capacitance	C/V
f	femto	prefix	10^{-15}
G	giga	prefix	10^{9}
Gy	gray	absorbed dose	J/kg
g	gram	mass	kg/1000
H	henry	inductance	Wb/A
Hz	hertz	frequency	1/s

Table 3 SI Symbols

Symbol	Name	Quantity	Formula
h	hecto	prefix	10^2
ha	hectare	area	$10\ 000\ m^2$
J	joule	energy, work, heat	N·m
K	kelvin	temperature	base unit
k	kilo	prefix	10^3
kg	kilogram	mass	base unit
L	litre	volume	$m^3/1000$
lm	lumen	luminous flux	cd·sr
lx	lux	illuminance	lm/m
M	mega	prefix	10^6
m	metre	length	base unit
m	milli	prefix	10^{-3}
mol	mole	amount of substance	base unit
μ *or* u	micro	prefix	10^{-6}
N	newton	force	$kg·m/s^2$
n	nano	prefix	10^{-9}
Ω *or* O	ohm	electric resistance	V/A
P	peta	prefix	10^{15}
Pa	pascal	pressure, stress	N/m^2
p	pico	prefix	10^{-12}
rad	radian	plane angle	dimensionless
S	siemens	electric conductance	A/V
Sv	sievert	dose equivalent	J/kg

Table 3 SI Symbols

Symbol	Name	Quantity	Formula
s	second	time	base unit
sr	steradian	solid angle	dimensionless
T	tera	prefix	10^{12}
T	tesla	magnetic flux density	Wb/m^2
t	tonne, metric ton	mass	1000 kg; Mg
V	volt	electric potential	W/A
W	watt	power, radiant flux	J/s
Wb	weber	magnetic flux	V · s

3.2 SI has no abbreviations—only symbols. Therefore, no periods follow a symbol except at the end of a sentence.

Examples: SI, not S.I.; s, not sec; A, not amp

3.3 Symbols appear in lower case unless the unit name has been taken from a proper name. In this case, the first letter of the symbol is capitalized.

Examples: m, metre; W, watt; Pa, pascal

Exception: L, litre

3.4 Symbols and prefixes are printed in upright (roman) type regardless of the type style in surrounding text.

Example: . . . a distance of 56 km between . . .

3.5 Unit symbols are the same whether singular or plural.

Examples: 1 kg, 14 kg; 1 mm, 25 mm

3.6 Leave a space between the value and the symbol.

Examples: 55 mm, not 55mm; 100 W, not 100W

Exception: No space is left between the numerical value and symbol for degree Celsius and degree of plane angle (e.g., 20°C, not 20 °C or 20° C; 45°, not 45 °). Note: Symbol for degree Celsius is °C; for coulomb, C.

3.7 Do not mix symbols and names in the same expression.

Examples:

m/s or metres per second, *not* metres/second; *not* metres/s
J/kg or joules per kilogram, *not* joules/kilogram; *not* joules/kg

3.8 Symbol for product—use the raised dot (·).

Examples: N·m; mPa·s; W/(m^2 ·K)

3.9 Symbol for quotient—use a solidus (/) or a negative exponent. Note: Use only one solidus per expression.

Examples:

m/s; ms^{-1}
m/s^2 or (m/s)/s, *not* m/s/s
kJ/(kg·K) or (kJ/kg)/K, *not* kJ/kg/K

3.10 Place modifying terms such as electrical, alternating current, etc. parenthetically after the symbol with a space in between.

Examples:

MW (e), *not* MWe; *not* MW(e)
V (ac), *not* Vac; *not* V(ac)
kPa (gage), *not* kPa(gage); *not* KPa gage

4 Prefixes

4.1 Most prefixes indicate orders of magnitude in steps of 1000. Prefixes provide a convenient way to express large and small numbers and to eliminate nonsignificant digits and leading zeros in decimal fractions. Some prefixes are listed in Table 4.

Examples:

126 000 watts is the same as 126 kilowatts
0.045 metre is the same as 45 millimetres
65 000 metres is the same as 65 kilometres

4.2 To realize the full benefit of the prefixes when expressing a quantity by numerical value, choose a prefix so that the number lies between 0.1 and 1000. For simplicity, give preference to prefixes representing 1000 raised to an integral power (e.g., µm, mm, km).

Exceptions:

1. For area and volume, the prefixes hecto, deka, deci, and centi are sometimes used; for example, cubic decimetre (L), square hectometre (hectare), cubic centimetre.
2. Tables of values of the same quantity.
3. Comparison of values.
4. For certain quantities in particular applications. For example, the millimetre is used for linear dimensions in engineering drawings even when the values lie far outside the range of 0.1 mm to 1000 mm; the centimetre is usually used for body measurements and clothing sizes.

Table 4 SI Prefixes

Prefix	Pronunciation	Symbol	Represents
exa	ex'a (a as in about)	E	10^{18}
peta	pet a (e as in pet, a as in about)	P	10^{15}
tera	as in terra firma	T	10^{12}
giga	jig'a (i as in jig, a as in about)	G	10^{9}
mega	as in megaphone	M	10^{6}
kilo	kill oh	k	10^{3} = 1000
hecto	heck toe	h*	10^{2} = 100
deka	deck a (a as in about)	da*	10^{1} = 10
deci	as in decimal	d*	10^{-1} = 0.1
centi	as in centipede	c*	10^{-2} = 0.01
milli	as in military	m	10^{-3} = 0.001
micro	as in microphone	p	10^{-6}
nano	nan oh (an as in ant)	n	10^{-9}
pico	peek oh	p	10^{-12}

4.3 **Compound units.** A compound unit is a derived unit expressed with two or more units. The prefix is attached to a unit in the numerator.

Examples:

V/m *not* mV/mm
mN·m *not* N·mm (torque)
MJ/kg not kJ/g

4.4 Compound prefixes formed by a combination of two or more prefixes are not used. Use only one prefix.

Examples:

2 nm *not* 2 mmm
6 MPa *not* 6 kkPa

4.5 **Exponential Powers.** An exponent attached to a symbol containing a prefix indicates that the multiple (of the unit with its prefix) is raised to the power of 10 expressed by the exponent.

Examples:

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

5 Numbers

5.1 **Large Numbers.** International practice separates the digits of large numbers into groups of three, counting from the decimal to the left and to the right, and inserts a space to separate the groups. In numbers of four digits, the space is not necessary except for uniformity in tables.

Examples: 2.345 678; 73 846; 635 041; 600.000; 0.113 501; 7 258

5.2 **Small Numbers.** When writing numbers less than one, always put a zero before the decimal marker.

Example: 0.046

5.3 **Decimal Marker.** The recommended decimal marker is a dot on the line (period). (In some countries, a comma is used as the decimal marker.)

5.4 **Billion.** Because billion means a thousand million in the United States and a million million in most other countries, avoid using the term in technical writing.

5.5 **Roman Numerals.** Do not use M to indicate thousands (MBtu for a thousand Btu), nor MM to indicate millions, nor C to indicate hundreds; they conflict with SI prefixes.

6 Words

6.1 The units in the international system of units are called SI units—not Metric Units and not SI Metric Units. (Inch-Pound units are called I-P units—not conventional units, not U.S. customary units, not English units, and not Imperial units.)

6.2 Treat all spelled out names as nouns. Therefore, do not capitalize the first letter of a unit except at the beginning of a sentence or in capitalized material such as a title.

Examples: watt; pascal; ampere; volt; newton; kelvin

Exception: Always capitalize the first letter of Celsius.

6.3 Do not begin a sentence with a unit symbol—either rearrange the words or write the unit name in full.

6.4 Use plurals for spelled out words when required by the rules of grammar.

Examples: metre — metres; henry — henries; kilogram — kilograms; kelvin — kelvins

Irregular: hertz — hertz; lux — lux; siemens — siemens

6.5 Do not put a space or hyphen between the prefix and unit name.

Examples: kilometre, not kilo metre or kilo-metre; milliwatt, not milli watt or milli-watt

6.6 When a prefix ends with a vowel and the unit name begins with a vowel, retain and pronounce both vowels.

Example: kiloampere

Exceptions: hectare; kilohm; megohm

6.7 When compound units are formed by multiplication, leave a space between units that are multiplied.

Examples: newton metre, not newton-metre; volt ampere, not volt-ampere

Table 5 SI Units for HVAC&R Catalogs

Quantity	Unit
Boilers	
Heat output	kW
Heat input	kW
Heat release	kW/m^2
Steam generation rate	kg/s
Fuel firing rate:	
solid	kg/s
gaseous	L/s
liquid	kg/s, L/s
Volume flow rate (combustion products)	m^3/s, L/s
Power input (to drives)	kW
Operating pressure	kPa
Hydraulic resistance	kPa
Draft conditions	Pa
Coil, Cooling and Heating	
Heat exchange rate	kW
Primary medium:	
mass flow rate	kg/s
hydraulic resistance	kPa
Air volume flow rate	m^3/s, L/s
Airflow static pressure loss	Pa
Face area	m^2
Fin spacing, center to center	mm
Controls and Instruments	
Flow rate:	
mass	kg/s
volume	m^3/s, L/s, mL/s
Operating pressure	kPa

Table 5 SI Units for HVAC&R Catalogs

Quantity	Unit
Hydraulic resistance	kPa
Rotational frequency	rev/s (rpm)*
Cooling Towers	
Heat extraction rate	kW
Volume flow rate:	
air	m^3/s, L/s
water	m^3/s, L/s
Power input (to drive)	kW
Diffusers and Grilles	
Air volume flow rate	m^3/s, L/s
Airflow pressure loss	Pa
Velocity	m/s
Fans	
Air volume flow rate	m^3/s, L/s
Power input (to drive)	kW
Fan static pressure	Pa
Fan total pressure	Pa
Rotational frequency	rev/s (rpm)*
Outlet velocity	m/s
Air Filters	
Air volume flow rate	m^3/s, L/s
Static pressure loss	Pa
Face area	m^2
Fuels	
Heating value:	
solid	MJ/kg
gaseous	MJ/m^3
liquid	MJ/kg

Table 5 SI Units for HVAC&R Catalogs

Quantity	Unit
Heat Exchangers	
Heat output	kW
Mass flow rate	kg/s
Hydraulic resistance	kPa
Operating pressure	kPa
Flow velocity	m/s
Heat exchange surface	m^2
Fouling factor	m^2/W
Induction Terminals	
Heating or cooling output	kW
Primary air volume flow rate	m^3/s, L/s
Primary air static pressure loss	Pa
Secondary water mass flow rate	kg/s
Secondary water hydraulic resistance	kPa
Pumps	
Mass flow rate	kg/s
Volume flow rate	L/s
Power input (to drive)	kW
Developed pressure	kPa
Operating pressure	kPa
Rotational frequency	rev/s (rpm)*
Space Heating Apparatus	
Heat output	kW
Airflow volume flow rate	m^3/s, L/s
Power input (to drive)	kW
Primary medium mass flow rate	kg/s
Hydraulic resistance	kPa
Operating pressure	kPa

Table 5 SI Units for HVAC&R Catalogs

Quantity	Unit
Airflow static pressure loss	Pa
Vessels	
Operating pressure	kPa
Volumetric capacity	m^3, L
Air Washers	
Volume flow rate:	
air	m^3/s, L/s
water	m^3/s, L/s
Mass flow rate, water	kg/s
Power input (to drive)	kW
Airflow static pressure loss	Pa
Hydraulic resistance	kPa
Water Chillers	
Cooling capacity	kW
Mass flow rate, water	kg/s
Power input (to drive)	kW
Refrigerant pressure	kPa
Hydraulic resistance	kPa

*Acceptable

6.8 Use the modifier squared or cubed after the unit name.

Example: metre per second squared

Exception: For area or volume, place the modifier before the units (e.g., square millimetre, cubic metre)

6.9 When compound units are formed by division, use the word *per*, not a solidus (/).

Examples: metre per second, not metre/second; watt per square metre, not watt/square metre

7 Conversions and Substitutions

7.1 **Conversions** are produced by multiplying the original value by a factor, then rounding so that it implies the same accuracy as in the original units. The same number of significant digits should be retained in the converted value. To convert a value, multiply it by the conversion factor (as found in Tables 6 and 7) and then round to the appropriate number of significant digits. For example, to convert 3 feet 6 7/8 inches to metres:

$$(3 \text{ ft} \cdot 0.3048 \text{ m/ft}) + (6.875 \text{ in} \cdot 0.0254 \text{ m/in}) = 1.089\,025 \text{ m},$$
$$\text{which rounds to } 1.089 \text{ m}.$$

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 acceptable accuracy.

7.2 **Significant digits** are defined as those “necessary to define a numerical value of a quantity” (IEEE/ASTM 2011). Identification of significant digits requires a judgment based on the context of the original measurement or rounding. For example, a drawing notation of “4 ft above finished floor” is unlikely to require a converted SI value of 1.2192 m; a more reasonable value is 1.2 m or 1200 mm.

7.3 **Substitutions** define a new rational value for the measurement, using the original value as a guide in selecting a logical size in the alternative units.

Examples:

1. A 100 yard foot race converts to 91.44 m; however, a substitution of 100 m is made, for a more rational race distance.
2. A 12 in. pipe size converts to 305 mm. However, if a more logical SI pipe size is 300 mm, to match the size available where a project will be built, 300 mm would be a substitution.

7.4 Generally, for projects in which items from one system of units must fit together with those using another system, conversions should be used. Substitutions should be used when the entire item or system can be specified with the new, more logical value.

7.5 The terms *conversion* and *substitution* should be used to differentiate between direct conversions and the choice of a new size for a value. The terms *hard conversion* and *soft conversion* should not be used.

REFERENCES

ASHRAE. 2013. Chapter 38, Units and conversions. In *ASHRAE Handbook*—Fundamentals.

IEEE/ASTM. 2011. *American National Standard for Metric Practice.* ANSI/IEEE/ ASTM SI 10™-2010. Institute of Electrical and Electronics Engineers, New York; ASTM International, West Conshohocken, PA.

Table 6 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 (avoir.)	grain	ounce (avoir.)	kg
	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	= 5.787×10^{-4}	= 4.329×10^{-3}	= 0.0163871	= 1.63871×10^{-5}
	1728*	1	7.48052	28.317	0.028317
	231.0*	0.13368	1	3.7854	0.0037854
	61.02374	0.035315	0.264173	1	0.001*
	6.102374×10^{4}	35.315	264.173	1000*	1

Energy	Btu	$ft \cdot lb_f$	calorie (cal)	joule (J) = watt-second (W·s)	watt-hour (W·h)
	1	= 778.17	= 251.9958	= 1055.056	= 0.293071
	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

Note: MBtu, which is 1000 Btu, is confusing and should not be used.

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

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

Viscosity (absolute) 1 poise = 1 dyne-sec/cm^2 = 0.1 Pa·s = 1 g/(cm·s)

poise	$lb_f \cdot s/ft^2$	$lb_f \cdot h/ft^2$	kg/(m·s) = N·s/m^2	$lb_m/ft \cdot s$
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 K	°C	°R	°F	Temperature Interval	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 acceptable accuracy.

Conversion spreadsheet available at www.ashrae.voila

Table 7 Conversions to I-P and SI Units

(Multiply I-P values by conversion factors to obtain SI; divide SI values by conversion factors to obtain I-P)

Multiply I-P	By	To Obtain SI
acre (43,560 ft^2)	0.4047	ha
	4046.873	m^2
atmosphere (standard)	*101.325	kPa
bar	*100	kPa
barrel (42 U.S. gal, petroleum)	159.0	L
	0.1580987	m^3
Btu (International Table)	1055.056	J
Btu (thermochemical)	1054.350	J
Btu/ft^2 (International Table)	11,356.53	J/m^2
Btu/ft^3 (International Table)	37,258.951	J/m^3
Btu/gal	278,717.1765	J/m^3
Btu·ft/h·ft^2·°F	1.730735	W/(m·K)
Btu·in/h·ft^2·°F (thermal conductivity k)	0.1442279	W/(m·K)
Btu/h	0.2930711	W
Btu/h·ft^2	3.154591	W/m^2
Btu/h·ft^2·°F (overall heat transfer coefficient U)	5.678263	W/(m^2·K)
Btu/lb	*2.326	kJ/kg
Btu/lb·°F (specific heat c_p)	*4.1868	kJ/(kg·K)
bushel (dry, U.S.)	0.0352394	m^3
calorie (thermochemical)	*4.184	J
centipoise (dynamic viscosity μ)	*1.00	mPa·s
centistokes (kinematic viscosity ν)	*1.00	mm^2/s
clo	0.155	(m^2·K)/W
dyne	1.0×10^{-5}	N
dyne/cm^2	*0.100	Pa
EDR hot water (150 Btu/h)	43.9606	W
EDR steam (240 Btu/h)	70.33706	W
EER	0.293	COP
ft	*0.3048	m
	*304.8	mm
ft/min, fpm	*0.00508	m/s
ft/s, fps	*0.3048	m/s
ft of water	2989	Pa
ft of water per 100 ft pipe	98.1	Pa/m
ft^2	0.092903	m^2
ft^2·h·°F/Btu (thermal resistance R)	0.176110	(m^2·K)/W
ft^2/s (kinematic viscosity ν)	92,900	mm^2/s
ft^3	28.316846	L
	0.02832	m^3
ft^3/min, cfm	0.471947	L/s
ft^3/s, cfs	28.316845	L/s
ft·lb$_f$ (torque or moment)	1.355818	N·m
ft·lb$_f$ (work)	1.356	J
ft·lb$_f$/lb (specific energy)	2.99	J/kg
ft·lb$_f$/min (power)	0.0226	W
footcandle	10.76391	lx
gallon (U.S., *231 in^3)	3.785412	L
gph	1.05	mL/s
gpm	0.0631	L/s
gpm/ft^2	0.6791	L/(s·m^2)
gpm/ton refrigeration	0.0179	mL/J
grain (1/7000 lb)	0.0648	g
gr/gal	17.1	g/m^3
gr/lb	0.143	g/kg
horsepower (boiler) (33,470 Btu/h)	9.81	kW
horsepower (550 ft·lb$_f$/s)	0.7457	kW
inch	*25.4	mm
in. of mercury (60°F)	3.3864	kPa
in. of water (60°F)	248.84	Pa
in/100 ft, thermal expansion coefficient	0.833	mm/m
To Obtain I-P	**By**	**Divide SI**

Multiply I-P	By	To Obtain SI
in·lb$_f$ (torque or moment)	113	mN·m
in^2	645.16	mm^2
in^3 (volume)	16.3874	mL
in^3/min (SCIM)	0.273117	mL/s
in^3 (section modulus)	16,387	mm^3
in^4 (section moment)	416,231	mm^4
kWh	*3.60	MJ
kW/1000 cfm	2.118880	kJ/m^3
kilopond (kg force)	9.81	N
kip (1000 lb$_f$)	4.45	kN
kip/in^2 (ksi)	6.895	MPa
litre	*0.001	m^3
met	58.15	W/m^2
micron (μm) of mercury (60°F)	133	mPa
mile	1.609	km
mile, nautical	*1.852	km
mile per hour (mph)	1.609344	km/h
	0.447	m/s
millibar	*0.100	kPa
mm of mercury (60°F)	0.133	kPa
mm of water (60°F)	9.80	Pa
ounce (mass, avoirdupois)	28.35	g
ounce (force or thrust)	0.278	N
ounce (liquid, U.S.)	29.6	mL
ounce inch (torque, moment)	7.06	mN·m
ounce (avoirdupois) per gallon	7.489152	kg/m^3
perm (permeance at 32°F)	5.72135×10^{-11}	kg/(Pa·s·m^2)
perm inch (permeability at 32°F)	1.45362×10^{-12}	kg/(Pa·s·m)
pint (liquid, U.S.)	4.73176×10^{-4}	m^3
pound		
lb (avoirdupois, mass)	0.453592	kg
	453.592	g
lb$_f$ (force or thrust)	4.448222	N
lb$_f$/ft (uniform load)	14.59390	N/m
lb/ft·h (dynamic viscosity μ)	0.4134	mPa·s
lb/ft·s (dynamic viscosity μ)	1490	mPa·s
lb$_f$·s/ft^2 (dynamic viscosity μ)	47.88026	Pa·s
lb/h	0.000126	kg/s
lb/min	0.007559	kg/s
lb/h [steam at 212°F (100°C)]	0.2843	kW
lb$_f$/ft^2	47.9	Pa
lb/ft^2	4.88	kg/m^2
lb/ft^3 (density ρ)	16.0	kg/m^3
lb/gallon	120	kg/m^3
ppm (by mass)	*1.00	mg/kg
psi	6.895	kPa
quad (10^{15} Btu)	1.055	EJ
quart (liquid, U.S.)	0.9463	L
square (100 ft^2)	9.2903	m^2
tablespoon (approximately)	15	mL
teaspoon (approximately)	5	mL
therm (U.S.)	105.5	MJ
ton, long (2240 lb)	1.016046	Mg
ton, short (2000 lb)	0.907184	Mg; t (tonne)
ton, refrigeration (12,000 Btu/h)	3.517	kW
torr (1 mm Hg at 0°C)	133	Pa
watt per square foot	10.76	W/m^2
yd	*0.9144	m
yd^2	0.8361	m^2
yd^3	0.7646	m^3
To Obtain I-P	**By**	**Divide SI**

*Conversion factor is exact.
Notes: 1. Units are U.S. values unless noted otherwise.
2. Litre is a special name for the cubic decimetre. 1 L = 1 dm^3 and 1 mL = 1 cm^3.

Source: ASHRAE (2013).