

# 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**

| <b>Quantity</b>           | <b>Name</b> | <b>Symbol</b> |
|---------------------------|-------------|---------------|
| 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**

| <b>Quantity</b>       | <b>Expression in Other SI Units</b> | <b>Name</b>    | <b>Symbol</b>      |
|-----------------------|-------------------------------------|----------------|--------------------|
| acceleration          |                                     |                |                    |
| angular               | $\text{rad}/\text{s}^2$             |                |                    |
| linear                | $\text{m}/\text{s}^2$               |                |                    |
| angle                 |                                     |                |                    |
| plane                 | dimensionless                       | radian         | rad                |
| solid                 | dimensionless                       | steradian      | sr                 |
| area                  | $\text{m}^2$                        |                |                    |
| Celsius temperature   | K                                   | degree Celsius | $^{\circ}\text{C}$ |
| conductivity, thermal | $\text{W}/(\text{m}\cdot\text{K})$  |                |                    |
| density               |                                     |                |                    |
| heat flux             | $\text{W}/\text{m}^2$               |                |                    |
| mass                  | $\text{kg}/\text{m}^3$              |                |                    |
| energy, enthalpy      |                                     |                |                    |
| work, heat            | $\text{N}\cdot\text{m}$             | joule          | J                  |
| specific              | $\text{J}/\text{kg}$                |                |                    |
| entropy               |                                     |                |                    |
| heat capacity         | $\text{J}/\text{K}$                 |                |                    |
| specific              | $\text{J}/(\text{kg}\cdot\text{K})$ |                |                    |
| flow, mass            | $\text{kg}/\text{s}$                |                |                    |

**Table 2 Selected SI Derived Units**

| <b>Quantity</b>        | <b>Expression in Other SI Units</b> | <b>Name</b> | <b>Symbol</b> |
|------------------------|-------------------------------------|-------------|---------------|
| flow, volume           | $\text{m}^3/\text{s}$               |             |               |
| force                  | $\text{kg}\cdot\text{m}/\text{s}^2$ | 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 <sup>2</sup>                    | pascal      | Pa            |
| resistance, electric   | V/A                                 | ohm         | $\Omega$ or Ω |
| velocity               |                                     |             |               |
| angular                | rad/s                               |             |               |
| linear                 | m/s                                 |             |               |
| viscosity              |                                     |             |               |
| dynamic (absolute) (m) | Pa·s                                |             |               |
| kinematic (n)          | $\text{m}^2/\text{s}$               |             |               |
| volume                 | $\text{m}^3$                        |             |               |
| volume, specific       | $\text{m}^3/\text{kg}$              |             |               |

## 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 ( $\text{km}^2$ ). The hectare is restricted to land or sea areas and equals 10 000  $\text{m}^2$ .

**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.

$$1 \text{ kilowatthour (kWh)} = 3.6 \text{ megajoules (MJ)}$$

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

$$1 \text{ watt (W)} = 1 \text{ joule per second (J/s)}$$

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

*Examples:*

$$\text{pressure or stress} = \text{N/m}^2 = \text{Pa (pascal)}$$

$$\text{work} = \text{N}\cdot\text{m} = \text{J (joule)}$$

$$\text{power} = \text{N}\cdot\text{m/s} = \text{W (watt)}$$

**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 ( $\text{m}^3/1000$ ); millilitre, mL; and microlitre,  $\mu\text{L}$ . No prefix other than m or  $\mu$  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) | $1/\text{s}$                  |
| C      | coulomb        | quantity of electricity      | $\text{A}\cdot\text{s}$       |
| °C     | degree Celsius | temperature                  | $^{\circ}\text{C} = \text{K}$ |
| 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         | $\text{C}/\text{V}$           |
| f      | femto          | prefix                       | $10^{-15}$                    |
| G      | giga           | prefix                       | $10^9$                        |
| Gy     | gray           | absorbed dose                | $\text{J}/\text{kg}$          |
| g      | gram           | mass                         | $\text{kg}/1000$              |
| H      | henry          | inductance                   | $\text{Wb}/\text{A}$          |
| Hz     | hertz          | frequency                    | $1/\text{s}$                  |

**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        |
| $\mu$ or u    | micro    | prefix               | $10^{-6}$        |
| N             | newton   | force                | $kg\cdot m/s^2$  |
| n             | nano     | prefix               | $10^{-9}$        |
| $\Omega$ or O | ohm      | electric resistance  | V/A              |
| P             | peta     | prefix               | $10^{15}$        |
| Pa            | pascal   | pressure, stress     | N/m <sup>2</sup> |
| 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 | $\text{Wb}/\text{m}^2$    |
| 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         | $\text{V} \cdot \text{s}$ |

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 ( $\cdot$ ).

*Examples:* N $\cdot$ m; mPa $\cdot$ s; W/(m $^2$   $\cdot$  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 $\cdot$ 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.,  $\mu$ m, 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                   | $\mu$  | $10^{-6}$         |
| 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:*

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

## 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                         |
|--|------------------------------|
| <b>Boilers</b>                         |                              |
| Heat output                            | kW                           |
| Heat input                             | kW                           |
| Heat release                           | kW/m <sup>2</sup>            |
| 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 <sup>3</sup> /s, L/s       |
| Power input (to drives)                | kW                           |
| Operating pressure                     | kPa                          |
| Hydraulic resistance                   | kPa                          |
| Draft conditions                       | Pa                           |
| <b>Coil, Cooling and Heating</b>       |                              |
| Heat exchange rate                     | kW                           |
| Primary medium:                        |                              |
| mass flow rate                         | kg/s                         |
| hydraulic resistance                   | kPa                          |
| Air volume flow rate                   | m <sup>3</sup> /s, L/s       |
| Airflow static pressure loss           | Pa                           |
| Face area                              | m <sup>2</sup>               |
| Fin spacing, center to center          | mm                           |
| <b>Controls and Instruments</b>        |                              |
| Flow rate:                             |                              |
| mass                                   | kg/s                         |
| volume                                 | m <sup>3</sup> /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)*                |
| <b>Cooling Towers</b>        |                             |
| Heat extraction rate         | kW                          |
| Volume flow rate:            |                             |
| air                          | $\text{m}^3/\text{s}$ , L/s |
| water                        | $\text{m}^3/\text{s}$ , L/s |
| Power input (to drive)       | kW                          |
| <b>Diffusers and Grilles</b> |                             |
| Air volume flow rate         | $\text{m}^3/\text{s}$ , L/s |
| Airflow pressure loss        | Pa                          |
| Velocity                     | m/s                         |
| <b>Fans</b>                  |                             |
| Air volume flow rate         | $\text{m}^3/\text{s}$ , L/s |
| Power input (to drive)       | kW                          |
| Fan static pressure          | Pa                          |
| Fan total pressure           | Pa                          |
| Rotational frequency         | rev/s (rpm)*                |
| Outlet velocity              | m/s                         |
| <b>Air Filters</b>           |                             |
| Air volume flow rate         | $\text{m}^3/\text{s}$ , L/s |
| Static pressure loss         | Pa                          |
| Face area                    | $\text{m}^2$                |
| <b>Fuels</b>                 |                             |
| Heating value:               |                             |
| solid                        | MJ/kg                       |
| gaseous                      | MJ/m <sup>3</sup>           |
| liquid                       | MJ/kg                       |

**Table 5 SI Units for HVAC&R Catalogs**

| Quantity                             | Unit                   |
|--------------------------------------|------------------------|
| <b>Heat Exchangers</b>               |                        |
| Heat output                          | kW                     |
| Mass flow rate                       | kg/s                   |
| Hydraulic resistance                 | kPa                    |
| Operating pressure                   | kPa                    |
| Flow velocity                        | m/s                    |
| Heat exchange surface                | m <sup>2</sup>         |
| Fouling factor                       | m <sup>2</sup> /W      |
| <b>Induction Terminals</b>           |                        |
| Heating or cooling output            | kW                     |
| Primary air volume flow rate         | m <sup>3</sup> /s, L/s |
| Primary air static pressure loss     | Pa                     |
| Secondary water mass flow rate       | kg/s                   |
| Secondary water hydraulic resistance | kPa                    |
| <b>Pumps</b>                         |                        |
| 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)*           |
| <b>Space Heating Apparatus</b>       |                        |
| Heat output                          | kW                     |
| Airflow volume flow rate             | m <sup>3</sup> /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**

| <b>Quantity</b>              | <b>Unit</b>            |
|------------------------------|------------------------|
| Airflow static pressure loss | Pa                     |
| <b>Vessels</b>               |                        |
| Operating pressure           | kPa                    |
| Volumetric capacity          | m <sup>3</sup> , L     |
| <b>Air Washers</b>           |                        |
| Volume flow rate:            |                        |
| air                          | m <sup>3</sup> /s, L/s |
| water                        | m <sup>3</sup> /s, L/s |
| Mass flow rate, water        | kg/s                   |
| Power input (to drive)       | kW                     |
| Airflow static pressure loss | Pa                     |
| Hydraulic resistance         | kPa                    |
| <b>Water Chillers</b>        |                        |
| 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.