

Australian/New Zealand Standard®

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**Conversion factors**

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## AS/NZS 1376:1996

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## PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME/71 on Quantities, Units and Conversions to supersede AS 1376—1973.

This edition incorporates the following major changes to the previous edition:

- (a) The layout and format of this Standard have been updated.
- (b) The conversion factors to convert SI units to imperial and other non-SI units in Section 2 have been deleted.
- (c) Some conversion factors to convert imperial units to SI units are contained in the National Measurement Regulation.
- (d) Units that are not used, have been deleted from the list of units in Section 3.
- (e) A new Appendix 'SI Prefixes' has been introduced.

References have been made to AS 1000, *The International System of Units (SI) and its application*, AS 2849, *Density of water—Numerical value* and AS 2851, *Density of mercury—Numerical value*.

The term 'informative' has been used in this Standard to define the application of the appendix to which it applies. An 'informative' appendix is only for information and guidance.

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## STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

## Australian/New Zealand Standard

## Conversion factors

## SECTION 1 SCOPE AND BASIS FOR THE FACTORS

**1.1 SCOPE** This Standard sets out basic conversion information for use in converting from imperial and other non-SI units to those of the International System of Units (SI).

NOTE: All exact conversion factors are given in bold type.

**1.2 SI UNITS** AS 1000 describes the system of metric units (SI), its application and definitions.

**1.3 NON-SI UNITS****1.3.1 Length**

$$1 \text{ yard} = 0.9144 \text{ m}$$

In U.S.A., an additional unit, the US survey foot, is legally recognized solely for measurements of the US Coast and Geodetic Survey. The conversion is expressed as follows:

$$\begin{aligned} 1 \text{ US survey foot} &= 1.000\,0020 \text{ ft} \\ &= 1200/3937 \text{ m} \end{aligned}$$

**1.3.2 Area**

$$\begin{aligned} 1 \text{ square yard} &= (0.9144 \text{ m})^2 \\ &= 0.836\,127\,36 \text{ m}^2 \end{aligned}$$

The hectare (ha), used for land areas, is expressed as follows:

$$1 \text{ ha} = 10\,000 \text{ m}^2$$

**1.3.3 Volume**

$$\begin{aligned} 1 \text{ cubic yard} &= (0.9144 \text{ m})^3 \\ &= 0.764\,554\,857\,984 \text{ m}^3 \end{aligned}$$

The litre (l or L) used in this Standard is that adopted by the Comité International des Poids et Mesures (CIPM) in 1964 when it was declared that litre shall be a special name for the cubic decimetre. (See Note 1.)

$$\begin{aligned} 1 \text{ gallon} &= 0.004\,546\,09 \text{ m}^3 \\ &= 4.546\,09 \text{ litres (see Note 2)} \end{aligned}$$

The US gallon is smaller and is equal to 231 cubic inches. It is used for the measurement of liquids only.

$$\begin{aligned} 1 \text{ US gallon} &= 0.003\,785\,411\,784 \text{ m}^3 \\ &= 3.785\,411\,784 \text{ litres} \end{aligned}$$

**NOTES:**

- Before 1964, the term 'litre' was that defined in 1901 as the unit of volume occupied by a mass of 1 kilogram of pure water at its maximum density and at standard atmospheric pressure. This meant that 1 litre was equivalent to 1.000 028 dm<sup>3</sup>. To avoid any confusion therefore, the word 'litre' should not be used in work involving high precision.
- The gallon, pint and fluid ounce in this Standard are units of the imperial system unless otherwise qualified by the letters 'US'.

**1.3.4 Plane angle** The degree ( . . . °) is defined as 1/360th part of a circle.

The value of  $\pi$  used in this Standard is given as follows:

$$\pi = 3.141\ 592\ 654$$

from which it is derived that—

$$1\ \text{rad} = 57.295780^\circ$$

The units degree, minute and second, although not themselves SI units, are acceptable for use with SI units.

### 1.3.5 Mass

$$1\ \text{pound} = 0.453\ 592\ 37\ \text{kg}$$

NOTE: The ounce and pound used in this Standard are avoirdupois unless otherwise stated.

The tonne (t) is a name for the megagram, i.e.  $1\ \text{t} = 1\ \text{Mg} = 1000\ \text{kg}$ .

**1.3.6 Mass per unit length** The tex (tex) is a unit adopted by the International Organization for Standardization (ISO) to express the mass per unit length of a textile filament or yarn and is given as follows:

$$1\ \text{tex} = 10^{-6}\ \text{kg/m} = 1\ \text{g/km}$$

NOTE: The kilotex (ktex) and the millitex (mtex) are recommended as the preferred multiple and sub-multiple respectively of the tex. The decitex (dtex) is also used.

**1.3.7 Force** The kilogram-force (kgf), also called kilopond (kp) in some European countries, is defined as that force which if applied to a body having a mass of 1 kilogram gives it an acceleration equal to standard gravity.

Standard gravity is expressed as follows:

$$g_n = 9.806\ 65\ \text{m/s}^2$$

from which it may be deduced that—

$$1\ \text{kgf} = 1\ \text{kp} = 9.806\ 65\ \text{N}$$

NOTE: In imperial units, standard gravity is equivalent to  $(9.806\ 65/0.3048)\ \text{ft/s}^2$ , i.e.  $32.174\ 048\ 56\ \text{ft/s}^2$  (rounded to 10 significant figures).

### 1.3.8 Pressure

**1.3.8.1 Standard atmosphere** The standard atmosphere (atm), sometimes referred to as atmosphere, is an international reference condition and is expressed as follows:

$$1\ \text{atm} = 101\ 325\ \text{Pa}$$

It is not to be regarded or used as a unit, but is of great importance and in widespread use as a reference condition.

**1.3.8.2 Barometric pressure** In meteorology, barometric pressure is expressed as follows:

$$\begin{aligned} 1\ \text{mbar} &= 100\ \text{Pa} \\ &= 1\ \text{hPa} \end{aligned}$$

**1.3.8.3 Pressure exerted by a column of liquid** The pressure ( $p$ ) exerted by a column of liquid depends on the density ( $\rho$ ) of the liquid and the acceleration of free fall (acceleration due to gravity).

The acceleration of free fall depends on the latitude and height above sea level, and ranges from  $9.785\ \text{m/s}^2$  at the equator to  $9.8325\ \text{m/s}^2$  at the poles. The value is to be appropriate to the precision with which the head of the liquid can be measured.

The density ( $\rho$ ) of the liquid depends on the temperature ( $t$ ) of the liquid, its purity and the pressure ( $p$ ) on the liquid.

For density of water ( $H_2O$ ), see AS 2849.

$$\rho = 998.2031 \text{ kg/m}^3 \text{ (rounded to 7 significant figures), if}$$

$$t = 20^\circ\text{C and } p = 101\,325 \text{ Pa}$$

If the following conditions of water apply:

- (a)  $\rho$  at  $20^\circ\text{C} = 998.2031 \text{ kg/m}^3$   
 (b)  $g = 9.806\,65 \text{ m/s}^2$ , then the pressures exerted by the following columns of water are—
- (i) 1 ft of  $H_2O$  =  $9.806\,65 \text{ m/s}^2 \times 998.2031 \text{ kg/m}^3 \times 0.3048 \text{ m/ft}$   
 = 2983.6959 Pa;
  - (ii) 1 in of  $H_2O$  =  $9.806\,65 \text{ m/s}^2 \times 998.2031 \text{ kg/m}^3 \times 0.0254 \text{ m/in}$   
 = 248.641 32 Pa; and
  - (iii) 1 mm of  $H_2O$  =  $9.806\,65 \text{ m/s}^2 \times 998.2031 \text{ kg/m}^3 \times 0.001 \text{ m/mm}$   
 = 9.789 028 4 Pa

NOTE: Factors given elsewhere in this Standard are based on the above conditions.

For density of mercury (Hg), see AS 2851.

$$\rho = 13\,595.08 \text{ kg/m}^3, \text{ if}$$

$$t = 20^\circ\text{C and } p = 101\,325 \text{ Pa.}$$

If the following conditions of mercury apply:

- (A)  $\rho$  at  $0^\circ\text{C} = 13\,595.08 \text{ kg/m}^3$   
 (B)  $g = 9.806\,65 \text{ m/s}^2$ , then the pressures exerted by the following columns of mercury are—
- (1) 1 in of Hg =  $9.806\,65 \text{ m/s}^2 \times 13\,595.08 \text{ kg/m}^3 \times 0.0254 \text{ m/in}$   
 = 3386.3837 Pa; and
  - (2) 1 mm of Hg =  $9.806\,65 \text{ m/s}^2 \times 13\,595.08 \text{ kg/m}^3 \times 0.001 \text{ m/mm}$   
 = 133.322 19 Pa

NOTE: Factors given elsewhere in this Standard are based on the above conditions.

**1.3.8.4 Torr** This unit is closely allied to the mm.Hg but expressed on a different basis—

$$1 \text{ torr} = \frac{101\,325}{760} = 133.322\,37 \text{ Pa}$$

**1.3.9 Temperature** Temperature may be measured by reference to a number of scales, such as Kelvin (K), Celsius ( $^\circ\text{C}$ ), Fahrenheit ( $^\circ\text{F}$ ) and Rankine ( $^\circ\text{R}$ ). If  $T$  K,  $t$   $^\circ\text{C}$ ,  $f$   $^\circ\text{F}$  and  $r$   $^\circ\text{R}$  represent the same temperature on the above four scales respectively, then—

$$t = T - 273.15$$

$$T = 5/9 (f + 459.67)$$

$$T = 5/9 r$$

NOTE: Celsius was formerly called Centigrade. The term Centigrade was abandoned by CIPM as an SI unit for temperature in 1948 because 'grade' was in use as the name for a right angle and 'centigrade' was a small angle, one hundredth of a right angle.

### 1.3.10 Energy and work

**1.3.10.1 Joule** The SI unit of energy and work is the joule (J).

**1.3.10.2 Calorie** The calorie has a number of definitions, the most common of which is the international table calorie; abbreviation: IT calorie ( $\text{cal}_{\text{IT}}$ ). For this unit, the Fifth International Conference on Properties of Steam (London, July 1956) adopted the following expression:

$$1 \text{ cal}_{\text{IT}} = 4.1868 \text{ J}$$

This is the same as the calorie (cal) which is used in this Standard.

## NOTES:

- 1 15°C calorie ( $\text{cal}_{15}$ ). This is also known as the water calorie (abbreviation: water cal). For this unit, the CIPM (1950) adopted the following conversion factor:

$$1 \text{ cal}_{15} = 4.1855 \text{ J}$$

This factor is uncertain by 0.0005 J.

A larger derived unit, thermie (th) equal to  $10^6 \text{ cal}_{15}$  is also used, i.e.

$$1 \text{ th} = 4.1855 \text{ MJ}$$

- 2 Thermochemical calorie ( $\text{cal}_\text{th}$ ). For this unit, the following conversion factor is adopted:

$$1 \text{ cal}_\text{th} = 4.184 \text{ J}$$

**1.3.10.3 British thermal unit** The British thermal unit (Btu) also has a number of expressions but only one is now in common use.

For this unit, the Fifth International Conference on Properties of Steam (London, July 1956) adopted the following expression:

$$1 \text{ Btu/lb} = 2.326 \text{ J/g}$$

From this expression, the conversion factor from Btu to joules is given as follows:

$$1 \text{ Btu} = 1055.055 \text{ 852 62 J}$$

Because of experimental uncertainties, the conversion factor often quoted is as follows:

$$1 \text{ Btu} = 1055.06 \text{ J}$$

## NOTES:

- 1 The exact expression  $1 \text{ Btu/lb} = 2.326 \text{ J/g}$  rather than the rounded value 1055.06 is used to maintain the precision of factors to eight significant figures.
- 2 A larger derived unit, the therm, equal to 100 000 Btu is also used and the conversion factor often quoted is as follows:

$$1 \text{ therm} = 105.506 \text{ MJ}$$

- 3 Another unit recognized in Australia is the water British thermal unit (abbreviation: water Btu). This is equivalent to Btu (60°F), thus —

$$1 \text{ water Btu} = 1 \text{ Btu (60°F)} = 1054.54 \text{ J}$$

**1.3.11 Power**

$$\begin{aligned} 1 \text{ horsepower (hp)} &= 550 \text{ ft.lbf/s} \\ &= 745.699 \text{ 87 W} \end{aligned}$$

NOTE: The metric horsepower, e.g. cheval vapeur (ch or CV) or pferdestärke (PS), is equal to 75 kilogram-force metres per second from which it is deduced that —

$$\begin{aligned} 1 \text{ metric horsepower} &= 75 \times 9.806 \text{ 65 W} \\ &= 735.498 \text{ 75 W} \end{aligned}$$

## SECTION 2 CONVERSION FACTORS

**2.1 METHOD OF PRESENTATION** Conversion factors are given in Tables 1 to 44. Each table gives factors to convert imperial and non-SI metric units to SI units, their multiples or sub-multiples or other accepted units.

The following guidelines have been adopted in the presentation of the tables:

- (a) Units having a common characteristic are listed in groups where appropriate.
- (b) Units are arranged in order of magnitude with the smallest unit at the top of each table or group therein.

**2.2 USE OF TERM SPECIFIC** In accordance with international practice, the term 'specific' always means 'per unit mass', e.g. specific volume means volume per unit mass.

TABLE 1  
LENGTH

| Name of unit                | Conversion                                 |
|-----------------------------|--------------------------------------------|
| inch                        | 1 in = 25.4 mm<br>= 2.54 cm<br>= 0.025 4 m |
| foot                        | 1 ft = 0.304 8 m                           |
| yard                        | 1 yd = 0.914 4 m                           |
| fathom                      | 1 fm = 1.828 8 m                           |
| mile                        | 1 mile = 1.609 344 km                      |
| international nautical mile | 1 n mile = 1.852 km                        |

TABLE 2  
AREA

| Name of unit | Conversion                                                                                    |
|--------------|-----------------------------------------------------------------------------------------------|
| circular mil | 1 circular mil = $506.707\ 48 \times 10^{-6}$ mm <sup>2</sup>                                 |
| square inch  | 1 in <sup>2</sup> = 645.16 mm <sup>2</sup><br>= 6.451 6 cm <sup>2</sup>                       |
| square foot  | 1 ft <sup>2</sup> = 9.290 304 dm <sup>2</sup><br>= $92.903\ 04 \times 10^{-3}$ m <sup>2</sup> |
| square yard  | 1 yd <sup>2</sup> = 0.836 127 36 m <sup>2</sup>                                               |
| acre         | 1 ac = 4 046.856 422 4 m <sup>2</sup><br>= 0.404 685 642 24 ha                                |
| square mile  | 1 sq mile = 258.998 811 033 6 ha<br>= 2.589 988 110 336 km <sup>2</sup>                       |

**TABLE 3**  
**VOLUME**

| Name of unit     | Conversion        |   |                                                  |
|------------------|-------------------|---|--------------------------------------------------|
| cubic inch       | 1 in <sup>3</sup> | = | 16 387.064 mm <sup>3</sup>                       |
|                  |                   | = | 16.387 064 cm <sup>3</sup>                       |
| cubic foot       | 1 ft <sup>3</sup> | = | 28.316 846 592 × 10 <sup>-3</sup> m <sup>3</sup> |
|                  |                   | = | 28.316 846 592 × 10 <sup>3</sup> cm <sup>3</sup> |
| cubic yard       | 1 yd <sup>3</sup> | = | 0.764 554 857 984 m <sup>3</sup>                 |
| cubic foot       | 1 ft <sup>3</sup> | = | 28.316 846 592 L                                 |
| fluid ounce      | 1 fl oz           | = | 28.413 062 5 mL                                  |
| pint             | 1 pt              | = | 568.261 25 mL                                    |
| gallon           | 1 gal             | = | 4.546 09 L                                       |
| US fluid ounce   | 1 US fl oz        | = | 29.573 529 562 5 mL                              |
| pint             | 1 US pt           | = | 473.176 473 mL                                   |
| gallon           | 1 US gal          | = | 3.785 411 784 L                                  |
| superficial foot | 1 super ft        | = | 2.359 737 216 × 10 <sup>-3</sup> m <sup>3</sup>  |
| acre foot        | 1 ac.ft           | = | 1 233.481 837 547 52 m <sup>3</sup>              |
|                  |                   | = | 1.233 481 837 547 52 ML                          |

NOTES:

- 1 1 imp pint = 20 imp fluid oz.  
 2 1 US pint = 16 US fluid oz.  
 3 1 super foot = 1 square foot and 1 inch thick.

**TABLE 4**  
**SECOND MOMENT OF AREA**

| Name of unit                        | Conversion                        |   |                                                       |
|-------------------------------------|-----------------------------------|---|-------------------------------------------------------|
| inch <sup>4</sup>                   | 1 in <sup>4</sup>                 | = | 416 231.425 6 mm <sup>4</sup>                         |
|                                     |                                   | = | 41.623 142 56 cm <sup>4</sup>                         |
| inch <sup>2</sup> feet <sup>2</sup> | 1 in <sup>2</sup> ft <sup>2</sup> | = | 0.599 373 252 864 m <sup>2</sup> cm <sup>2</sup>      |
| foot <sup>4</sup>                   | 1 ft <sup>4</sup>                 | = | 8.630 974 841 241 6 × 10 <sup>-3</sup> m <sup>4</sup> |

**TABLE 5**  
**AREA PER UNIT LENGTH**

| Name of unit         | Conversion                                             |
|----------------------|--------------------------------------------------------|
| square inch per foot | 1 in <sup>2</sup> /ft = 2 116.666 7 mm <sup>2</sup> /m |

**TABLE 6**  
**MODULUS OF SECTION  
PER UNIT LENGTH**

| Name of unit        | Conversion                                            |
|---------------------|-------------------------------------------------------|
| inch cubed per foot | 1 in <sup>3</sup> /ft = 53 763.333 mm <sup>3</sup> /m |