Section

16

Metrification

Contents

16.0.0 Introduction to the 1975 Metric Conversion Act

As the federal government moves to convert the inch-pound units to the metric system, in accordance with the 1975 Metric Conversion Act, various parts of the construction industry will begin the conversion to this more universal method of measurement.

Metric units are often referred to as *SI units*, an abbreviation taken from the French: le Système International d'Unités. Another abbreviation that will be seen with more frequency is ISO—the International Standards Organization charged with supervising the establishment of a universal standards system. For everyday transactions it may be sufficient to gain only the basics of the metric system.

Name of metric unit	Symbol	Approximate size (length/pound)
meter	m	39½ inches
kilometer	km	0.6 mile
centimeter	cm	width of a paper clip
millimeter	mm	thickness of a dime
hectare	ha	2½ acres
square meter	m^2	1.2 square yards
gram	g	weight of a paper clip
kilogram	kg	2.2 pounds
metric ton	t	long ton (2240 pounds)
liter	L	one quart and two ounces
milliliter	mL	⅛ teaspoon
kilopascal	kPa	atmospheric pressure is about 100 Pa

The Celsius temperature scale is used. Instead of referring to its measurement as *degree centigrade*, the term *degree Celsius* is the correct designation. Using this term, familiar points are

- Water freezes at 0 degrees
- Water boils at 100 degrees
- Normal body temperature is 37 degrees (98.6 F)
- Comfortable room temperature 20 to 35 (68 to 77 F)

16.1.0 What Will Change and What Will Stay the Same?

Metric Module and Grid

What will change:

- The basic building module, from 4 inches to 100 mm.
- The planning grid, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- A module and grid based on rounded, easy-to-use dimensions. The 100 mm module is the global standard.

Drawings

What will change:

- Units, from feet and inches to millimeters for all building dimensions and to meters for site plans and civil engineering drawings. Unit designations are unnecessary: if there is no decimal point, it is millimeters; if there is a decimal point carried to one, two, or three places, it is meters. In accordance with ASTM E621, centimeters are not used in construction because (1) they are not con-

sistent with the preferred use of multiples of 1000, (2) the order of magnitude between a millimeter and centimeter is only 10 and the use of both units would lead to confusion and require the use of unit designations, and 93) the millimeter is small enough to almost entirely eliminate decimal fractions from construction documents.

- Drawing scales, from inch-fractions-to-feet to true rations. Preferred metric scales are:

  1:1 (full size)

  1:5 (close to 3" = 1'-0")

  1:10 (between 1" = 1'-0" and 1½" = 1'-0")

  1:20 (between ½" = 1'-0" and ¾" = 1'-0")

  1:50 (close to ¼" = 1'-0")

  1:100 (close to ⅛" = 1'-0")

  1:200 (close to 1/16" = 1'-0")

  1:500 (close to 1" = 40'-0")

  1:1000 (close to 1" = 80'-0")

As a means of comparison, inch-fraction scales may be converted to true ratios by multiplying a scale's divisor by 12; for example, for ¼" = 1'-0", multiply the 4 by 12 for a true ratio of 1:48.

- Drawing sizes, to ISO "A" series:

  A0 (1189 × 841 mm, 46.8 × 33.1 inches)

  A1 (841 × 594 mm, 33.1 × 23.4 inches)

  A2 (594 × 420 mm, 23.4 × 16.5 inches)

  A3 (420 × 297 mm, 16.5 × 11.7 inches)

  A4 (297 × 210 mm, 11.7 × 8.3 inches)

Of course, metric drawings can be made on any size paper.

What will stay the same:

- Drawing contents

Never use dual units (both inch-pound and metric) on drawings. It increases dimensioning time, doubles the chance for errors, makes drawings more confusing, and only postpones the learning process. An exception is for construction documents meant to be viewed by the general public.

Specifications

What will change:

- Units of measure, from feet and inches to millimeters for linear dimensions, from square feet to square meters for area, from cubic yards to cubic meters for volume (except use liters for fluid volumes), and from other inch-pound measures to metric measures as appropriate.

What will stay the same:

- Everything else in the specifications

Do not use dual units in specifications except when the use of an inch-pound measure serves to clarify an otherwise unfamiliar metric measure; then place the inch-pound unit in parentheses after the metric. For example, "7.5 kW (10 horsepower) motor." All unit conversions should be checked by a professional to ensure that rounding does not exceed allowable tolerances.

For more information, see the July–August 1994 issue of *Metric in Construction.*

Floor Loads

What will change:

- Floor load designations, from "psf" to kilograms per square meter (kg/m^2) for everyday use and kilonewtons per square meter (kN/m^2) for structural calculations.

What will stay the same:

- Floor load requirements

Kilograms per square meter often are used to designate floor loads because many live and dead loads (furniture, filing cabinets, construction materials, etc.) are measured in kilograms. However, kilonewtons per square meter or their equivalent, kilopascals, are the proper measure and should be used in structural calculations.

Construction Products

What will change:

- Modular products: brick, block, drywall, plywood, suspended ceiling systems, and raised floor systems. They will undergo "hard" conversion; that is, their dimensions will change to fit the 100 mm module.
- Products that are custom-fabricated or formed for each job (for example, cabinets, stairs, handrails, ductwork, commercial doors and windows, structural steel systems, and concrete work). Such products usually can be made in any size, inch-pound or metric, with equal ease; therefore, for metric jobs, they simply will be fabricated or formed in metric.

What will stay the same:

- All other products, since they are cut-to-fit at the jobsite (for example, framing lumber, woodwork, siding, wiring, piping, and roofing) or are not dimensionally sensitive (for example, fasteners, hardware, electrical components, plumbing fixtures, and HVAC equipment). Such products will just be "soft" converted—that is, relabeled in metric units. A 2¾" × 4½" wall switch face plate will be relabeled 70 × 115 mm and a 30 gallon tank, 114 L. Manufacturers eventually may convert the physical dimensions of many of these products to new rational "hard" metric sizes but only when it becomes convenient for them to do so.

"2-By-4" Studs and Other "2-By" Framing (Both Wood and Metal)

What will change:

- Spacing, from 16" to 400 mm, and 24" to 600 mm.

What will stay the same:

- Everything else.

"2-bys" are produced in "soft" fractional inch dimensions so there is no need to convert them to new rounded "hard" metric dimensions. 2-by-4s may keep their traditional name or perhaps they will eventually be renamed 50 by 100 (mm), or, more exactly, 38 × 39.

Drywall, Plywood, and Other Sheet Goods

What will change:

- Widths, from 4'–0" to 1200 mm.
- Heights, from 8'-0" to 2400 mm, 10'-0" to 3000 mm.

What will stay the same:

- Thicknesses, so fire, acoustic, and thermal ratings will not have to be recalculated.

Metric drywall and plywood are readily available but may require longer lead times for ordering and may cost more in small amounts until their use becomes more common.

Batt Insulation

What will change:

- Nominal width labels, from 16" to 16"/400 mm and 24" to 24"/600 mm.

What will stay the same:

- Everything else.

Batts will not change in width, they will just have a tighter "friction fit" when installed between metric-spaced framing members.

Doors

What will change:

- Height, from 6'-8" to 2050 mm or 2100 mm and from 7'-0" to 2100 mm.
- Width, from 2'-6" to 750 mm, from 2'-8" to 800 mm, from 2'-10" to 850 mm, from 3"-0" to 900 mm or 950 mm, and from 3'-4" to 1000 mm.

What will stay the same:

- Door thicknesses.
- Door materials and hardware.

For commercial work, doors and door frames can be ordered in any size since they normally are custom-fabricated.

Ceiling Systems

What will change:

- Grids and lay-in ceiling tile, air diffusers and recessed lighting fixtures, from 2' × 2' to 600 × 600 mm and from 2' × 4' to 600 × 1200 mm.

What will stay the same:

- Grid profiles, tile thicknesses, air diffuser capacities, fluorescent tubes, and means of suspension.

On federal building projects, metric recessed lighting fixtures may be specified if their total installed costs are estimated to be more than for inch-pound fixtures.

Raised Floor Systems

What will change:

- Grids and lay-in floor tile, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- Grid profiles, tile thicknesses, and means of support.

HVAC Controls

What will change:

- Temperature units, from Fahrenheit to Celsius.

What will stay the same:

- All other parts of the controls.

Controls are now digital so temperature conversions can be made with no difficulty.

Brick

What will change:

- Standard brick, to 90 × 57 × 190 mm.
- Mortar joints, from ⅜" and ½" to 10 mm.
- Brick module, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- Brick and mortar composition.

Of the 100 or so brick sizes currently made, 5 to 10 are within a millimeter of a metric brick so the brick industry will have no trouble supplying metric brick.

For more information, see the March–April 1995 issue of *Metric in Construction.*

Concrete Block

What will change:

- Block sizes, to 190 × 190 × 390 mm.
- Mortar joints, from ½" to 10 mm.
- Block module, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- Block and mortar composition.

On federal building projects, metric block may be specified if its total installed cost is estimated to be more than for inch-pound block. The Construction Metrication Council recommends that, wherever possible, block walls be designed and specified in a manner that permits the use of either inch-pound or metric block, allowing the final decision to be made by the contractor.

Sheet Metal

What will change:

- Designation, from "gage" to millimeters.

What will stay the same:

- Thickness, which will be soft-converted to tenths of a millimeter.

In specifications, use millimeters only or millimeters with the gage in parentheses.

Concrete

What will change:

- Strength designations, from "psi" to megapascals, rounded to the nearest 5 megapascals per ACI 318M as follows:

  2500 psi to 20 MPa
  3000 psi to 25 MPa
  3500 psi to 25 MPa
  4000 psi to 30 MPa
  4500 psi to 35 MPa
  5000 psi to 35 MPa

Depending on exact usage, however, the above metric conversions may be more exact than those indicated.

What will stay the same:

- Everything else.

For more information, see the November–December 1994 issue of *Metric in Construction.*

Rebar

What will change:

- Rebar will not change in size but will be renamed per ASTM A615M-96a and ASTM A706M-96a as follows:

No. 3 to No. 10	No. 9 to No. 29
No. 4 to No. 13	No. 10 to No. 32
No. 5 to No. 16	No. 11 to No. 36
No. 6 to No. 19	No. 14 to No. 43
No. 7 to No. 22	No. 18 to No. 57
No. 8 to No. 25	

What will stay the same:

- Everything else.

For more information, see the July–August 1996 issue of *Metric on Construction.*

Glass

What will change:

- Nominal pipe and fitting designations, from inches to millimeters.

What will stay the same:

- Pipe and fitting cross sections and threads.

Pipes and fittings are produced in "soft" decimal-inch dimensions but are identified in nominal-inch sizes as a matter of convenience. A 2-inch pipe has neither an inside nor an outside diameter of

2 inches, a 1-inch fitting has no exact 1-inch dimension, and a ½-inch sprinkler head contains no ½-inch dimension anywhere; consequently, there is no need to "hard" convert pipes and fittings to rounded metric dimensions. Instead, they will not change size but simply be relabeled in metric as follows:

⅛" = 6 mm	1½" = 40 mm
3/16" = 7 mm	2" = 50 mm
¼" = 8 mm	2½" = 65 mm
⅜" = 10 mm	3" = 75 mm
½" = 15 mm	3½" = 90 mm
⅝" = 18 mm	4" = 100 mm
¾" = 20 mm	4½" = 115 mm
1" = 25 mm	1" = 25 mm for all larger sizes
1¼" = 32 mm	

For more information, see the September–October 1993 issue of *Metric in Construction.*

Electrical Conduit

What will change:

- Nominal conduit designations, from inches to millimeters.

What will stay the same:

- Conduit cross sections.

Electrical conduit is similar to piping: it is produced in "soft" decimal-inch dimensions but is identified in nominal-inch sizes. Neither metallic nor nonmetallic conduit will change size; they will be relabeled in metric units as follows:

½" = 16 (mm)	2½" = 63 (mm)
¾" = 21 (mm)	3" = 78 (mm)
1" = 27 (mm)	3½" = 91 (mm)
1¼" = 35 (mm)	4" = 103 (mm)
1½" = 41 (mm)	5" = 129 (mm)
2" = 53 (mm)	6" = 155 (mm)

These new metric names were assigned by the National Electrical Manufacturers Association.

Electrical Wire

What will change:

- Nothing at this time.

What will stay the same:

- Existing American Wire Gage (AWG) sizes.

Structural Steel

What will change:

- Section designations, from inches to millimeters and from pounds per foot to kilograms per meter, in accordance with ASTM A6M.

- Bolts—to metric diameters and threads per ASTM A325M and A490M.

What will stay the same:

- Cross sections.

Like pipe and conduit, steel sections are produced in "soft" decimal-inch dimensions (with actual depths varying by weight) but are named in rounded-inch dimensions so there is no need to "hard" convert them to metric units. Rather, their names will be changed to metric designations, and rounded to the nearest 10 mm. Thus, a 10-inch section is relabeled as a 250-mm section and a 24-inch section is relabeled as a 610-mm section.

16.2.0 How Metric Units Will Apply in the Construction Industry

	Quantity	Unit	Symbol
Masonry	length	meter, millimeter	m, mm
	area	square meter	m^2
	mortar volume	cubic meter	m^3
Steel	length	meter, millimeter	m, mm
	mass	megagram (metric ton) kilogram	Mg (t) kg
	mass per unit length	kilogram per meter	kg/m
Carpentry	length	meter, millimeter	m, mm
Plastering	length	meter, millimeter	m, mm
	area	square meter	m^2
	water capacity	liter (cubic decimeter)	L (dm^3)
Glazing	length	meter, millimeter	m, mm
	area	square meter	m^2
Painting	length	meter, millimeter	m, mm
	area	square meter	m^2
	capacity	liter (cubic decimeter) milliliter (cubic centimeter)	L (dm^3) mL (cm^3)
Roofing	length	meter, millimeter	m, mm
	area	square meter	m^2
	slope	percent ratio of lengths	% mm/mm, m/m
Plumbing	length	meter, millimeter	m, mm
	mass	kilogram, gram	kg, g
	capacity	liter (cubic decimeter)	L (dm^3)
	pressure	kilopascal	kPa
Drainage	length	meter, millimeter	m, mm
	area	hectare (10 000 m2) square meter	ha m^2
	volume	cubic meter	m^3
	slope	percent ratio of lengths	% mm/mm, m/m
HVAC	length	meter, millimeter	m, mm
	volume (capacity)	cubic meter liter (cubic decimeter)	m^3 L (dm^3)
	air velocity	meter/second	m/s
	volume flow	cubic meter/second liter/second (cubic decimeter per second)	m^3/s L/s (dm^3/s)
	temperature	degree Celsius	°C
	force	newton, kilonewton	N, kN
	pressure	pascal, kilopascal	Pa, kPa
	energy	kilojoule, megajoule	kJ, MJ
	rate of heat flow	watt, kilowatt	W, kW
Electrical	length	millimeter, meter, kilometer	mm, m, km
	frequency	hertz	Hz
	power	watt, kilowatt	W, kW
	energy	megajoule kilowatt hour	MJ kWh
	electric current	ampere	A
	electric potential	volt, kilovolt	V, kV
	resistance	milliohm, ohm	mΩ, Ω

16.3.0 Metrification of Pipe Sizes

Pipe diameter sizes can be confusing because their designated size does not correspond to their actual size. For instance, a 2-inch steel pipe has an inside diameter of approximately 2⅛ inches and an outside diameter of about 2⅜ inches.

The *2 inch* designation is very similar to the 2" × 4" designation for wood studs, neither dimensions are "actual," but they are a convenient way to describe these items.

Pipe sizes are identified as *NPS* (*nominal pipe size*) and their conversion to metric would conform to ISO (International Standards Organization) criteria and are referred to as *DN* (*diameter nominal*). These designations would apply to all plumbing, mechanical, drainage, and miscellaneous pipe commonly used in civil works projects.

NPS size	*DN size*
⅛"	6 mm
3⁄16"	7 mm
¼"	8 mm
⅜"	10 mm
½"	15 mm
⅝"	18 mm
¾"	20 mm
1"	25 mm
1¼"	32 mm
1½"	40 mm
2"	50 mm
2½"	65 mm
3"	80 mm
3½"	90 mm
4"	100 mm
4½"	115 mm
5"	125 mm
6"	150 mm
8"	200 mm
10"	250 mm
12"	300 mm
14"	350 mm
16"	400 mm
18"	450 mm
20"	500 mm
24"	600 mm
28"	700 mm
30"	750 mm
32"	800 mm
36"	900 mm
40"	1000 mm
44"	1100 mm
48"	1200 mm

NPS size	*DN size*
52"	1300 mm
56"	1400 mm
60"	1500 mm

For all pipe over 60-inches nominal, use 1 inch equals 25 mm.

16.4.0 Metrification of Standard Lumber Sizes

Metric units: ASTM Standard E-380 was used as the authoritative standard in developing the metric dimensions in this standard. Metric dimensions are calculated at 25.4 millimeters (mm) times the actual dimension in inches. The nearest mm is significant for dimensions greater than 1/8 inch, and the nearest 0.1 mm is significant for dimensions equal to ore less than 1/8 inch.

The rounding rule for dimensions greater than 1/8 inch: If the digit in the tenth of mm position (the digit after the decimal point) is less than 5, drop all fractional mm digits; if it is greater than 5 or if it is 5 followed by at least one nonzero digit, round one mm higher; if 5 followed by only zeroes, retain the digit in the unit position (the digit before the decimal point) if it is even, or increase it one mm if it is odd.

The rounding rule for dimensions equal to or less than 1/8 inch: if the digit in the hundredths of mm position (the second digit after the decimal point) is less than 5, drop all digits to the right of the tenth position; if greater than or it is 5 followed by at least one nonzero digit, round one-tenth mm higher; if 5 followed by only zeros, retain the digit in the tenths position if it is even or increase it one-tenth mm if it is odd.

In case of a dispute on size measurements, the conventional (inch) method of measurement shall take precedence.

16.5.0 Metric Rebar Conversions

A615 M-96a & A706M-96a Metric Bar Sizes	Nominal Diameter	A615-96a & A706-96a Inch-Pound Bar Sizes
#10	9.5 mm/0.375"	#3
#13	12.7 mm/0.500"	#4
#16	15.9 mm/0.625"	#5
#19	19.1 mm/0.750"	#6
#22	22.2 mm/0.875"	#7
#25	25.4 mm/1.000"	#8
#29	28.7 mm/1.128"	#9
#32	32.3 mm/1.270"	#10
#36	35.8 mm/1.410"	#11
#43	43.0 mm/1.693"	#14
#57	57.3 mm/2.257"	#18

16.6.0 Metric Conversion of ASTM Diameter and Wall Thickness Designations

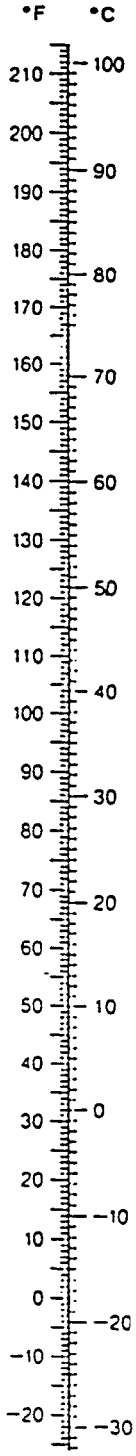
Metric conversion of ASTM diameter designations

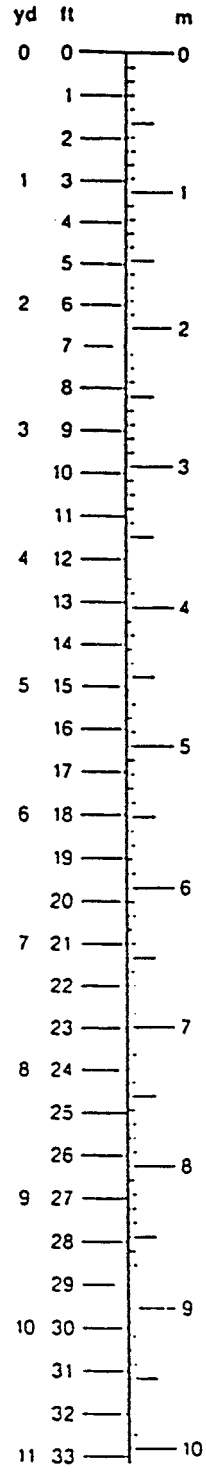
in	mm	in	mm	in	mm	in	mm
6	150	30	750	57	1425	96	2400
8	200	33	825	60	1500	102	2550
10	250	36	900	63	1575	108	2700
12	300	39	975	66	1650	114	2850
15	375	42	1050	69	1725	120	3000
18	450	45	1125	72	1800	132	3300
21	525	48	1200	78	1950	144	3600
24	600	51	1275	84	2100	156	3900
27	675	54	1350	90	2250	168	4200

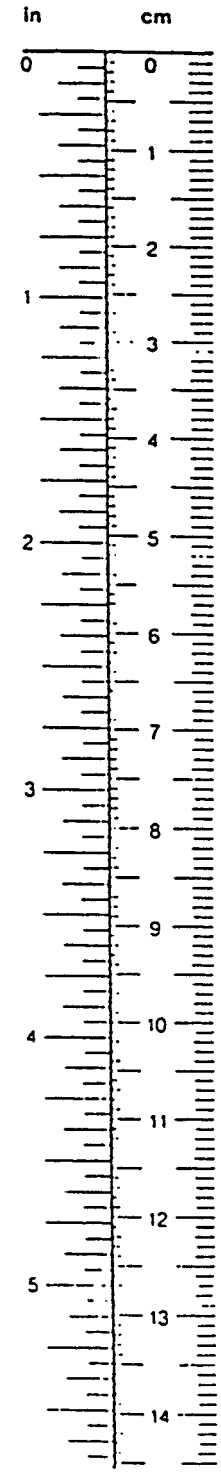
Metric conversion of ASTM wall thickness designations

in	mm	in	mm	in	mm	in	mm
1	25	3-1/8	79	5	125	8	200
1-1/2	38	3-1/4	82	5-1/4	131	8-1/2	213
2	50	3-1/2	88	5-1/2	138	9	225
2-1/4	56	3-3/4	94	5-3/4	144	9-1/2	238
2-3/8	59	3-7/8	98	6	150	10	250
2-1/2	63	4	100	6-1/4	156	10-1/2	263
2-5/8	66	4-1/8	103	6-1/2	163	11	275
2-3/4	69	4-1/4	106	6-3/4	169	11-1/2	288
2-7/8	72	4-1/2	113	7	175	12	300
3	75	4-3/4	119	7-1/2	188	12-1/2	313

16.7.0 Metric Conversion Scales (Temperature and Measurements)

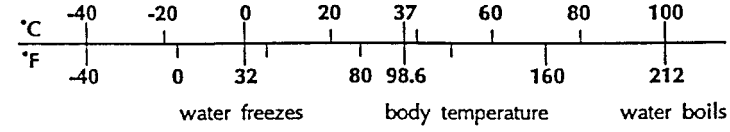






16.8.0 Approximate Metric Conversions

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1,000 kg)	1.1	short tons	
		VOLUME		
mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in^3
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	degrees Celsius	multiply by 9/5, add 32	degrees Fahrenheit	°F



(U.S. Department of Commerce Technology Administration, Office of Metric Programs, Washington, DC 20230.)

16.8.0 Approximate Metric Conversions—Continued

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
		VOLUME		
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	degrees Fahrenheit	subtract 32, multiply by 5/9	degrees Celsius	°C

(United States Department of Commerce, Technology Administration, National Institute of Standards and Technology, Metric Program, Gaithersburg, Maryland 20899.)

16.9.0 Quick Imperial (Metric Equivalents)

Distance

Imperial		Metric	Metric		Imperial
1 inch	= 2.540	centimetres	1 centimetre	= 0.3937	inch
1 foot	= 0.3048	metre	1 decimetre	= 0.3281	foot
1 yard	= 0.9144	metre	1 metre	= 3.281	feet
1 rod	= 5.029	metres		= 1.094	yard
1 mile	= 1.609	kilometres	1 decametre	= 10.94	yards
			1 kilometre	= 0.6214	mile

Weight

1 ounce (troy)	= 31.103 grams	1 gram	= 0.032 ounce (troy)
1 ounce (avoir)	= 28.350 grams	1 gram	= 0.035 ounce (avoir)
1 pound (troy)	= 373.242 grams	1 kilogram	= 2.679 pounds (troy)
1 pound (avoir)	= 453.592 grams	1 kilogram	= 2.205 pounds (avoir)
1 ton (short)	= 0.907 tonne*	1 tonne	= 1.102 ton (short)

*1 tonne = 1000 kilograms

Capacity

Imperial		U.S.	
1 pint	= 0.568 litre	1 pint (U.S.)	= 0.473 litre
1 gallon	= 4.546 litres	1 quart (U.S.)	= 0.946 litre
1 bushel	= 36.369 litres	1 gallon (U.S.)	= 3.785 litres
1 litre	= 0.880 pint	1 barrel (U.S.)	= 158.98 litres
1 litre	= 0.220 gallon		
1 hectolitre	= 2.838 bushels		

Area

1 square inch	= 6.452 square centimetres
1 square foot	= 0.093 square metre
1 square yard	= 0.836 square metre
1 acre	= 0.405 hectare*
1 square mile	= 259.0 hectares
1 square mile	= 2.590 square kilometres
1 square centimetre	= 0.155 square inch
1 square metre	= 10.76 square feet
1 square metre	= 1.196 square yard
1 hectare	= 2.471 acres
1 square kilometre	= 0.386 square mile

*1 hectare = 1 square hectometre

Volume

1 cubic inch	= 16.387	cubic centimetres
1 cubic foot	= 0.0283	cubic decimetres
1 cubic yard	= 0.765	cubic metre
1 cubic centimetre	= 0.061	cubic inch
1 cubic decimetre	= 35.314	cubic foot
1 cubic metre	= 1.308	cubic yard

16.10.0 Metric Conversion Factors

The following list provides the conversion relationship between U.S. customary units and SI (International System) units. The proper conversion procedure is to multiply the specified value on the left (primarily U.S. customary values) by the conversion factor exactly as given below and then round to the appropriate number of significant digits desired. For example, to convert 11.4 ft to meters: 11.4 × 0.3048 = 3.47472, which rounds to 3.47 meters. Do not round either value before performing the multiplication, as accuracy would be reduced. A complete guide to the SI system and its use can be found in ASTM E 380, Metric Practice.

To convert from	to	multiply by
Length		
inch (in.)	micron (μ)	25,400 E*
inch (in.)	centimeter (cm)	2.54 E
inch (in.)	meter (m)	0.0254 E
foot (ft)	meter (m)	0.3048 E
yard (yd)	meter (m)	0.9144
Area		
square foot (sq ft)	square meter (sq m)	0.09290304 E
square inch (sq in.)	square centimeter (sq cm)	6.452 E
square inch (sq in.)	square meter (sq m)	0.00064516 E
square yard (sq yd)	square meter (sq m)	0.8361274
Volume		
cubic inch (cu in.)	cubic centimeter (cu cm)	16.387064
cubic inch (cu in.)	cubic meter (cu m)	0.00001639
cubic foot (cu ft)	cubic meter (cu m)	0.02831685
cubic yard (cu yd)	cubic meter (cu m)	0.7645549
gallon (gal) Can. liquid	liter	4.546
gallon (gal) Can. liquid	cubic meter (cu m)	0.004546
gallon (gal) U.S. liquid**	liter	3.7854118
gallon (gal) U.S. liquid	cubic meter (cu m)	0.00378541
fluid ounce (fl oz)	milliliters (ml)	29.57353
fluid ounce (fl oz)	cubic meter (cu m)	0.00002957
Force		
kip (1000 lb)	kilogram (kg)	453.6
kip (1000 lb)	newton (N)	4,448.222
pound (lb) avoirdupois	kilogram (kg)	0.4535924
pound (lb)	newton (N)	4.448222
Pressure or stress		
kip per square inch (ksi)	megapascal (MPa)	6.894757
kip per square inch (ksi)	kilogram per square centimeter (kg/sq cm)	70.31
pound per square foot (psf)	kilogram per square meter (kg/sq m)	4.8824
pound per square foot (psf)	pascal (Pa)†	47.88
pound per square inch (psi)	kilogram per square centimeter (kg/sq cm)	0.07031
pound per square inch (psi)	pascal (Pa)†	6,894.757
pound per square inch (psi)	megapascal (MPa)	0.00689476
Mass (weight)		
pound (lb) avoirdupois	kilogram (kg)	0.4535924
ton, 2000 lb	kilogram (kg)	907.1848
grain	kilogram (kg)	0.0000648
Mass (weight) per length		
kip per linear foot (klf)	kilogram per meter (kg/m)	0.001488
pound per linear foot (plf)	kilogram per meter (kg/m)	1.488
Mass per volume (density)		
pound per cubic foot (pcf)	kilogram per cubic meter (kg/cu m)	16.01846
pound per cubic yard (lb/cu yd)	kilogram per cubic meter (kg/cu m)	0.5933
Temperature		
degree Fahrenheit (°F)	degree Celsius (°C)	$t_C = (t_F - 32)/1.8$
degree Fahrenheit (°F)	degree Kelvin (°K)	$t_K = (t_F + 459.7)/1.8$
degree Kelvin (°K)	degree Celsius (C°)	$t_C = t_K - 273.15$
Energy and heat		
British thermal unit (Btu)	joule (J)	1055.056
calorie (cal)	joule (J)	4.1868 E
Btu/°F · hr · ft²	W/m² · °K	5.678263
kilowatt-hour (kwh)	joule (J)	3,600,000. E
British thermal unit per pound (Btu/lb)	calories per gram (cal/g)	0.55556
British thermal unit per hour (Btu/hr)	watt (W)	0.2930711
Power		
horsepower (hp) (550 ft-lb/sec)	watt (W)	745.6999 E
Velocity		
mile per hour (mph)	kilometer per hour (km/hr)	1.60934
mile per hour (mph)	meter per second (m/s)	0.44704
Permeability		
darcy	centimeter per second (cm/sec)	0.000968
feet per day (ft/day)	centimeter per second (cm/sec)	0.000352

*E indicates that the factor given is exact.
**One U.S. gallon equals 0.8327 Canadian gallon.
†A pascal equals 1.000 newton per square meter.

Note:
One U.S. gallon of water weighs 8.34 pounds (U.S.) at 60°F.
One cubic foot of water weighs 62.4 pounds (U.S.).
One milliliter of water has a mass of 1 gram and has a volume of one cubic centimeter.
One U.S. bag of cement weighs 94 lb.

The prefixes and symbols listed below are commonly used to form names and symbols of the decimal multiples and submultiples of the SI units.

Multiplication Factor	Prefix	Symbol
$1,000,000,000 = 10^9$	giga	G
$1,000,000 = 10^6$	mega	M
$1,000 = 10^3$	kilo	k
$1 = 1$	—	—
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000001 = 10^{-6}$	micro	μ
$0.000000001 = 10^{-9}$	nano	n