METRIC GUIDE

The following information is provided as a guide for utilizing the International System of Units (SI), generally referenced as "metric units". Related information can be found in AASHTO R1 "Metric Practice Guide", and ASTM E380, "Use of the International System of Units (SI)(The Modernized Metric System)".

Included herein are commonly used equivalents and conversions for U.S. Customary Units and Metric Units. It is not the intention of this guide to provide a detailed compilation of such equivalents and conversions. Such lists are available in many publications, including those referenced above.

One common conversion, which is found in many test procedures, is to determine an equivalent temperature in units of either degrees Celsius or degrees Fahrenheit.

Convert degrees Fahrenheit to degrees Celsius by:

$$°C = \frac{5}{9} \times (°F - 32)$$

Convert degrees Celsius to degrees Fahrenheit by:

$$°F = \left[\frac{9}{5} \times °C\right] + 32$$

Under the SI (Metric) system, the base unit for mass is the "kilogram". (Although not technically correct, "weight" is often used in common practice to mean "mass".) The base unit for length is the "meter". The base unit for time is the "second". Primary metric units for area and volume are the "square meter" and the "cubic meter", respectively.

In addition to expressing values in the base or primary metric units, other associated metric units are identified and determined by varying the magnitude of the base metric unit by powers of 10. Metric values are commonly shown in scientific notation form, (for example, $1 \times 10^4 = 10{,}000$; $1 \times 10^{-4} = 0.0001$).

Table 1 below gives a listing of prefixes used in the metric system, with their associated powers of ten, and their symbol.

TABLE 1

Prefix	Power of ten	Symbol
*deci	10^{-1}	d
*centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	p
femto	10^{-15}	f
atto	10^{-18}	a
*deka	10^{1}	da
*hecto	10^{2}	h
kilo	10^{3}	k
mega	10^{6}	M
giga	10^{9}	G
tera	10^{12}	T
peta	10^{15}	P
exa	10^{18}	E

* Use is to be avoided where practical. When expressing a quantity by a numerical value and a unit, a prefix should preferably be chosen so that the numerical value lies between 0.1 and 1000. In expressing area and volume, the prefixes hecto, deka, deci, and centi may be required, for example, square hectometer, cubic centimeter.

Table 2 below gives the symbols commonly used for various metric units.

TABLE 2

kg = kilogram
g = gram
mg = milligram
m = meter
km = kilometer
cm = centimeter
mm = millimeter
μm = micrometer (micron)
s = second
m^2 = square meter
cm^2 = square centimeter
mm^2 = square millimeter
m^3 = cubic meter
cm^3 or cc = cubic centimeter
mm^3 = cubic millimeter
L = liter
mL = milliliter
Pa = pascal
N = newton
kPa = kilopascal
MPa = megapascal

Table 3 below includes common conversions from the base and primary metric units (kilogram, meter, square meter, and cubic meter) to other associated metric units. Also listed are some common derived metric units.

TABLE 3

1 gram = 0.001 kilogram
1 milligram = 1 x 10^{-6} kilogram
1 milligram = 0.001 gram
1 kilogram = 1000 grams
1 metric ton = 1000 kilograms
1 kilometer = 1000 meters
1 centimeter = 0.01 meter
1 millimeter = 0.001 meter
1 micron (micrometer) = 1 x 10^{-6} meter
1 square kilometer = 1 x 10^{6} square meters
1 square centimeter = 1 x 10^{-4} square meter
1 square millimeter = 1 x 10^{-6} square meter
1 cubic centimeter = 1 x 10^{-6} cubic meter
1 cubic millimeter = 1 x 10^{-9} cubic meter
1 liter = 0.001 cubic meter
1 milliliter = 1 x 10^{-6} cubic meter
1 milliliter = 1 cubic centimeter
1 newton = 1 kg·m/s^2
1 pascal = 1 N/m^2
1 kilopascal = 1000 pascals
1 megapascal = 1 x 10^{6} pascals
1 poise (absolute viscosity) = 0.10 Pa·s
1 centistoke (kinematic viscosity) = 1 mm^2/s or 1 x 10^{-6} m^2/s

Some common U.S Customary units, with their corresponding base and primary metric unit equivalents, are given below in Table 4.

TABLE 4

1 pound (avoirdupois) = 0.453 5924 kilogram
1 ton (2000 lbs.) = 907.1847 kilograms
* 1 inch = 0.0254 meter
* 1 foot = 0.3048 meter
* 1 yard = 0.9144 meter
* 1 mile (5280 feet) = 1609.344 meters
* 1 square inch = 6.4516×10^{-4} square meter
* 1 square foot = 0.092 903 04 square meter
1 square yard = 0.836 1274 square meter
1 cubic inch = $1.638\ 706 \times 10^{-5}$ cubic meter
1 cubic foot = 0.028 316 85 cubic meter
1 cubic yard = 0.764 5549 cubic meter
1 pint (U.S. liquid) = $4.731\ 765 \times 10^{-4}$ cubic meter
1 quart (U.S. liquid) = $9.463\ 529 \times 10^{-4}$ cubic meter
1 gallon (U.S. liquid) = 0.003 785 412 cubic meter

(Exact equivalents are noted with an asterisk.)

Table 5 below lists commonly used conversions for U.S. Customary Units and metric units. Values are shown to the degree of accuracy which generally may be used to achieve satisfactory results. If more accuracy is desired, the values may be derived by using Tables 3 and 4.

TABLE 5

1 kilogram = 2.205 pounds
1 pound = 453.6 grams
1 ounce (avoirdupois) = 28.35 grams
1 ton (2000 lbs) = 0.9072 metric ton
1 meter = 39.37 inches or 3.281 feet
1 kilometer = 0.62 miles
* 1 mil = 0.0254 millimeters or 25.4 micrometers
* 1 inch = 2.54 centimeters or 25.4 millimeters
* 1 foot = 0.3048 meters
* 1 yard = 0.9144 meters
1 mile = 1.61 kilometers
1 square inch = 6.452 cm^2 or 645.16 mm^2
1 square foot = 0.0929 square meters
1 square yard = 0.836 square meters
1 cubic inch = 16.39 cm^3 or 16386 mm^3
1 cubic foot = 0.028 m^3 or 28317 cm^3
1 cubic yard = 0.765 cubic meters
1 liter = 1.06 quarts (U.S. liquid)
1 ounce (U.S. fluid) = 29.574 milliliter
1 pint (U.S. liquid) = 0.47 liter
1 quart (U.S. liquid) = 0.95 liter
1 gallon (U.S. liquid) = 3.79 liters
1 lb/ft^3 = 16.02 kg/m^3
1 kilometer/hour = 0.62 mile/hour
1 mile/hour = 1.61 km/hour
1 pound/square inch = 6.895 kPa
1 pound force = 4.448 newton
1 gallon/square yard = 4.527 $liters/m^2$
1 gallon/ton (2000 lbs.) = 4.173 liters/metric ton
1 gallon/cubic yard = 4.951 $liters/m^3$
1 pound/square yard = 0.542 kg/m^2
1 pound/cubic yard = 0.593 kg/m^3
1 pound/gallon = 0.120 kg/liter
1 cubic yard/square yard = 0.914 m^3/m^2
1 inch/mile = 0.0158 meter/kilometer

(Exact equivalents are noted with an asterisk.)

Table 6 below is from information contained in AASHTO M92 and ASTM E11 "Wire-Cloth Sieves for Testing Purposes", and shows Standard (Metric) and Alternative (U.S. Customary) sieve size designations. As shown, metric size designations are given in mm or μm. (1,000 μm = 1 millimeter)

8 inch diameter sieve = 203.2 mm diameter sieve
12 inch diameter sieve = 304.8 mm diameter sieve

TABLE 6

Sieve Designation		Sieve Designation	
Standard	Alternate	Standard	Alternate
125 mm	5 in.	2.36 mm	No. 8
106 mm	4.24 in.	2.00 mm	No. 10
100 mm	4 in.	1.70 mm	No. 12
90 mm	3-1/2 in.	1.40 mm	No. 14
75 mm	3 in.	1.18 mm	No. 16
63 mm	2-1/2 in.	1.00 mm	No. 18
53 mm	2.12 in.	850 μm	No. 20
50 mm	2 in.	710 μm	No. 25
45 mm	1-3/4 in.	600 μm	No. 30
37.5 mm	1-1/2 in.	500 μm	No. 35
31.5 mm	1-1/4 in.	425 μm	No. 40
26.5 mm	1.06 in.	355 μm	No. 45
25.0 mm	1 in.	300 μm	No. 50
22.4 mm	7/8 in.	250 μm	No. 60
19.0 mm	3/4 in.	212 μm	No. 70
16.0 mm	5/8 in.	180 μm	No. 80
13.2 mm	0.530 in.	150 μm	No. 100
12.5 mm	1/2 in.	125 μm	No. 120
11.2 mm	7/16 in.	106 μm	No. 140
9.5 mm	3/8 in.	90 μm	No. 170
8.0 mm	5/16 in.	75 μm	No. 200
6.7 mm	0.265 in.	63 μm	No. 230
6.3 mm	1/4 in.	53 μm	No. 270
5.6 mm	No. 3-1/2	45 μm	No. 325
4.75 mm	No. 4	38 μm	No. 400
4.00 mm	No. 5	32 μm	No. 450
3.35 mm	No. 6	25 μm	No. 500
2.80 mm	No. 7	20 μm	No. 635

TABLE 7

SI* (METRIC) CONVERSION FACTORS

(Approximate equivalents, except as noted)**

CONVERSIONS TO SI UNITS					CONVERSIONS FROM SI UNITS				
Abbrev./Symbol	*When you know*	*Multiply by*	*To find*	*Symbol*	*Symbol*	*When you know*	*Multiply by*	*To find*	*Abbrev./Symbol*
LENGTH					**LENGTH**				
in.	inches	25.4**	millimeters	mm	mm	millimeters	0.03937	inches	in.
ft.	feet	0.3048**	meters	m	m	meters	3.28	feet	ft.
yd.	yards	0.9144**	meters	m	m	meters	1.09	yards	yd.
mi.	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi.
AREA					**AREA**				
sq. in. or in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.0016	square inches	sq. in. or in^2
sq. ft. or ft^2	square feet	0.093	square meters	m^2	m^2	square meters	10.764	square feet	sq. ft. or ft^2
sq. yd. or yd^2	square yards	0.836	square meters	m^2	m^2	square meters	1.19	square yards	sq. yd. or yd^2
	acres	0.405	hectares	ha	ha	hectares	2.47	acres	
sq. mi. or mi^2	square miles	2.59	square kilometers	km^2	km^2	square kilometers	0.386	square miles	sq. mi. or mi^2
VOLUME					**VOLUME**				
fl. oz.	fluid ounces	29.57	milliliters	mL	mL	millimeters	0.034	fluid ounces	fl. oz.
gal.	gallons (liquid)	3.7854	liters***	L	L	liters***	0.264	gallons (liquid)	gal.
cu. ft. or ft^3	cubic feet	0.028	cubic meters	m^3	m^3	cubic meters	35.315	cubic feet	cu. ft. or ft^3
cu. yd. or yd^3	cubic yards	0.765	cubic meters	m^3	m^3	cubic meters	1.31	cubic yards	cu. yd. or yd^3
MASS					**MASS**				
oz.	ounces	28.35	grams	g	g	grams	0.035	ounces	oz.
lb.	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb.
T	short tons (2000 lb)	0.907	metric tons****	t	t	metric tons****	1.102	short tons (2000 lb)	T
T	short tons (2000 lb)	0.907	megagrams****	Mg	Mg	megagrams****	1.102	short tons (2000 lb)	T

* SI is the symbol for the International System of Units.

** Exact equivalent.

*** Metric volumes greater than 1000 liters should be shown in m^3. The following conversion factors are helpful in making necessary conversions:
1 liter = 0.001 cubic meter; 1 cubic meter = 264.17 gallons (liquid).

**** 1 metric ton = 1000 kilograms = 1,000,000 grams = 1 Mg.